DAVID W. TAYLOR NAVAL SHIP
RESEARCH AND DEVELOPMENT CENTER

Bethesda, Maryland 20084

PERFORMANCE OF MULTIPLE-DISK-ROTOR PUMPS WITH VARIED INTERDISK SPACINGS

by
Joseph H. Morris

PROPULSION AND AUXILIARY SYSTEMS DEPARTMENT
RESEARCH AND DEVELOPMENT REPORT

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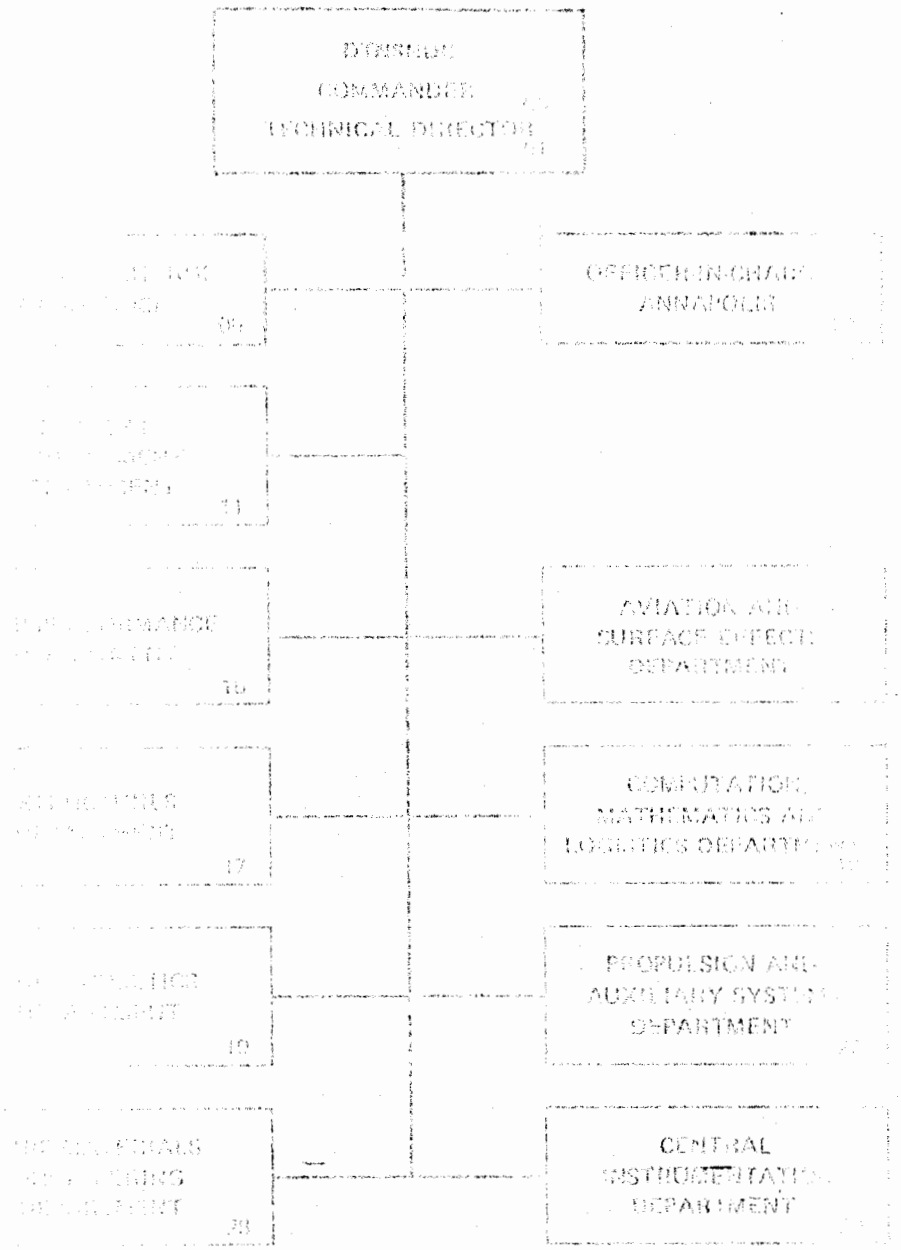

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Disk-rotor pumps having various configurations with interdisk spacings ranging from 0.006 to 0.26 inch (0.15 to 6.6 millimeters) were investigated at operating speeds from 3550 to 7000 revolutions per minute. Operating data for the pumps with the various rotors is included. Good performance at wide interdisk spacings was obtained.

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LIST OF ABBREVIATIONS

bhp	Brake horsepower
^{o}C	Degrees Celsius
cm	Centimeters
diam	Diameter
^{o}F	Degrees Fahrenheit
gpm	Gallons per minute
ID	Inside diameter
kg	Kilogram
ℓ	Liter
lbf	Pounds of force
lbm	Pounds of mass
min	Minute
mm	Millimeter
OD	Outside diameter
psi	Pounds per square inch
psig	Pounds per square inch (gage)
rms	Root mean square average for surface roughness
rpm	Revolutions per minute

ABSTRACT

Disk-rotor pumps having various configurations with interdisk spacings ranging from 0.006 to 0.26 inch (0.15 to 6.6 millimeters) were investigated at operating speeds from 3550 to 7000 revolutions per minute. Operating data for the pumps with the various rotors is included. Good performance at wide interdisk spacings was obtained.

ADMINISTRATIVE INFORMATION

This work was authorized under Task Area SF 43 433 01 on the Auxiliary Machinery Exploratory Development Program, Work Unit 2723-103. The investigation was sponsored by the Naval Sea Systems Command (SEA 05R14).

BACKGROUND

Disk-type pump rotors transfer energy to the fluid through frictional forces between the rotor and the pumped fluid. For the rotor shown in Figure 1, fluid enters the disk space at the rotor inside diameter (ID),* is accelerated by frictional forces, making several revolutions within the rotor before being discharged. Patents on the concept were awarded to N. Tesla early in this century.

Navy interest in disk-rotor pumps stems from the reported cavitation insensitivity at high rotating speeds and from high theoretical efficiencies indicated in recent publications.[1,2]** Higher allowable pump rotating speeds, with attendant higher head rise per stage and fewer required pumping stages, could allow significant size, weight, and complexity reductions in certain naval pumping applications. With these potential payoffs in mind, the Navy decided to explore the disk pump.

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*Definitions of abbreviations used are given on page ix.

**A complete listing of references is given on page 83.

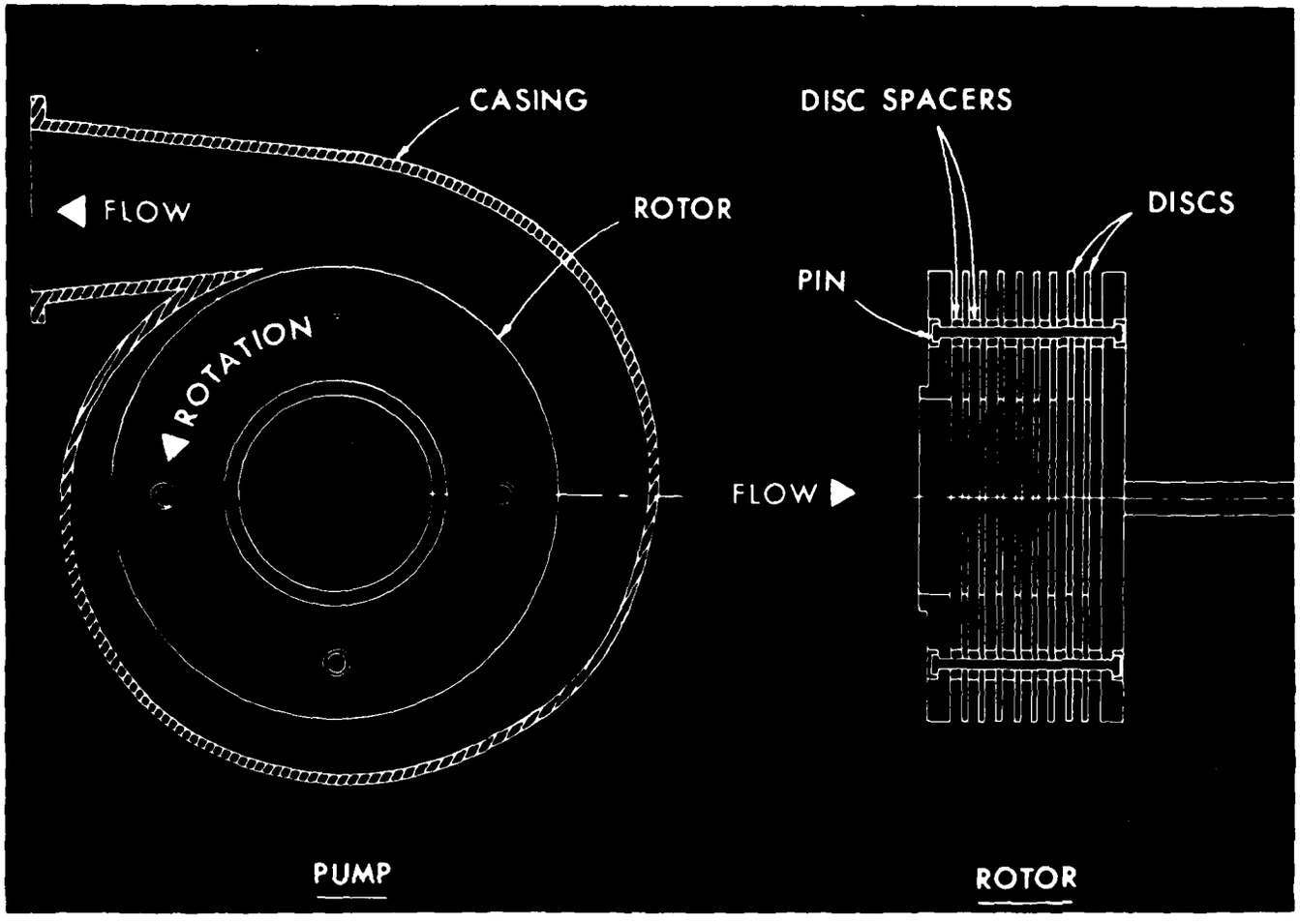

Figure 1 - Sectional View of Disk Pump and Rotor Assembly with Volute Casing

APPROACH

The approach selected was to fabricate pumps consistent with the design parameters recommended by Crawford and Rice[2] and to investigate the performance of these pumps in an actual pumping system under closely controlled and monitored conditions.

EQUIPMENT

The investigation was initiated with a modified commercial-design pump built by Northern Dynamics, Inc., of Detroit, Michigan. This unit was equipped with an overhung shaft, a single-suction 10-in.-diam disk rotor, and a volute casing. Mechanical face seals were installed at both the suction and shaft sides of the impeller to limit leakage for laboratory data collection. Flexibility in pump rotor design was achieved through use of relatively heavy front and back plates connected by through-bolts (pins) upon which the pumping portion of the rotor is mounted, as shown schematically in Figure 1. Interdisk spacing was maintained by installing spacer washers of the appropriate thickness on each through-bolt between adjacent disks. This construction allows both the disk spacing and the disk thickness to be varied while maintaining the overall width of the rotor. The particular rotor design was equipped with a total of ten through-bolts, four equally spaced on a 4-in. (102-mm)-diam bolt circle, and six equally spaced on a 7.5-in. (191-mm)-diam bolt circle. The spacer washers used had a 1/2-in. (12.7-mm) ID and a 3/4-in. (19.1-mm) OD. Shaft stiffness, rotor mounting method, and power requirements limited operating speeds for this pump to about 3550 rpm.

SIX-INCH-DIAMETER PUMP

A second-generation disk pump was designed to provide a much stronger rotor mounting arrangement and a stiffer shaft with shorter overhang to allow higher operating speeds. A diffuser casing was utilized to reduce the substantial radial thrust loadings which can develop on the large rotor area required for low-flow disk rotors and in an attempt to improve pump overall efficiency through more efficient conversion of velocity head to static pressure.

The diffuser pump casing is shown in Figures 2-4. Each of the five diffuser channels has an inlet area of 0.04 $in.^2$ (25.8 mm^2), an area ratio of 2.78, and an included expansion angle of 7.6 degrees. Discharge from the diffuser ring is collected in a volute channel in the pump casing and leaves the casing through a conical diffuser with an inlet area of 0.58 $in.^2$ (3.7 mm^2), an area ratio of 2.87, and an included expansion angle of 8 degrees. Diffuser designs were developed using Runstadler, Dolan, and Dean,[3] Cockrell and Markland,[4] and Stepanoff[5] as guidelines.

ROTOR CONFIGURATIONS

The pump with a 6-in.-nominal-diam rotor incorporates 5.94-in. (151-mm)-OD disks located between heavy rotor end plates by through-bolts and spacers. A 2-in. (51-mm) space was available between end plates for installation of disks and spacers; a total of 17 bolts were utilized to ensure accurate control of interdisk space and to provide sufficient torque-transmitting capability. The spacer washers were 0.3-in. (7.6 mm) in OD, kept as small as practical for minimum flow disturbance within the rotor.

Mechanical face seals were again fitted both on the shaft side and on the suction side of the impeller to keep internal and external leakage to very low levels. Two rotor end-plate designs were provided. Initial operation was conducted with flat end plates, as shown in Figure 5. The flat-end-plate rotor discharges into a circular pump casing fitted with a diffuser ring. The second end-plate design, Figure 6, consisted of end plates shaped to extend around the ends of the disk stack (cupped end plates). These provide a rotating collector which accepts flow from the disk stack and discharges directly to the diffuser ring. The pump casing design was based on the rotor performance predicted using Crawford and Rice's[2] method.

The effects of different disk radius ratios (disk OD/disk ID) on performance were investigated using disks having IDs of 1.5 in. (38 mm) and 1.0 in. (25 mm) to provide radius ratios of 4:1 and 6:1, respectively. Data were taken for disks having smooth surface finishes (8-12 rms),

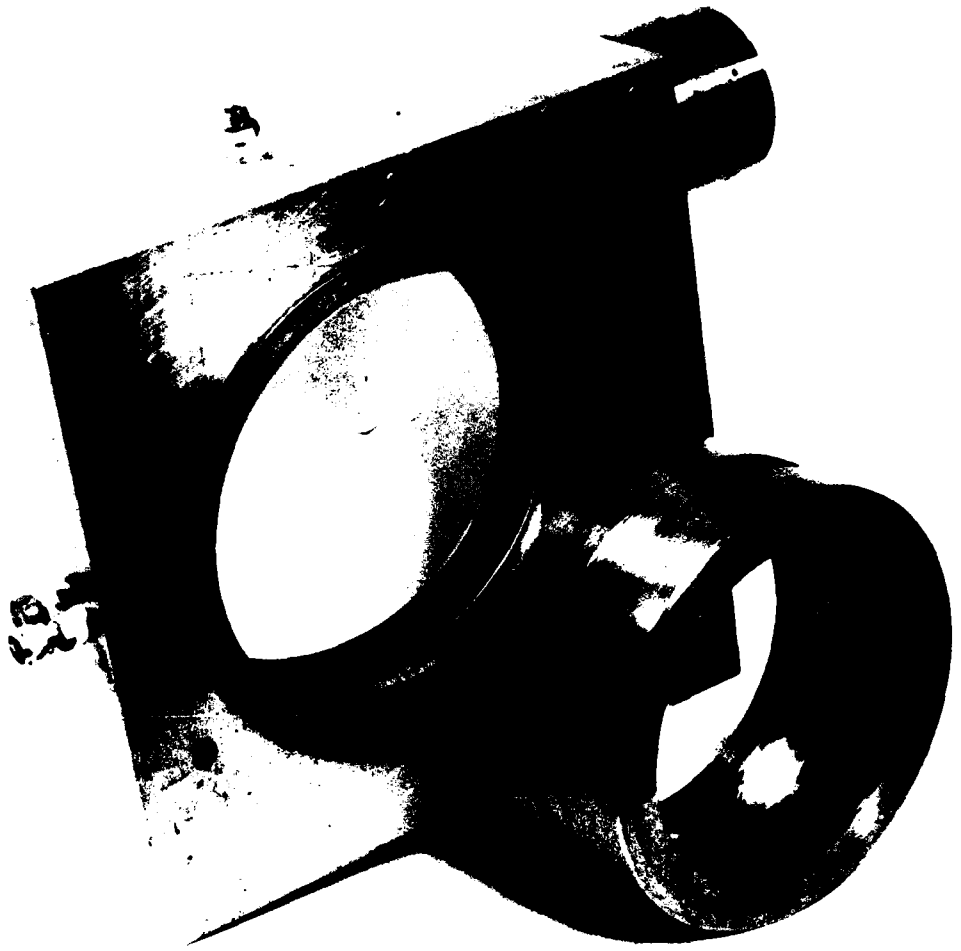

Figure 2 - Pump Casing Separated from Diffuser Ring Assembly

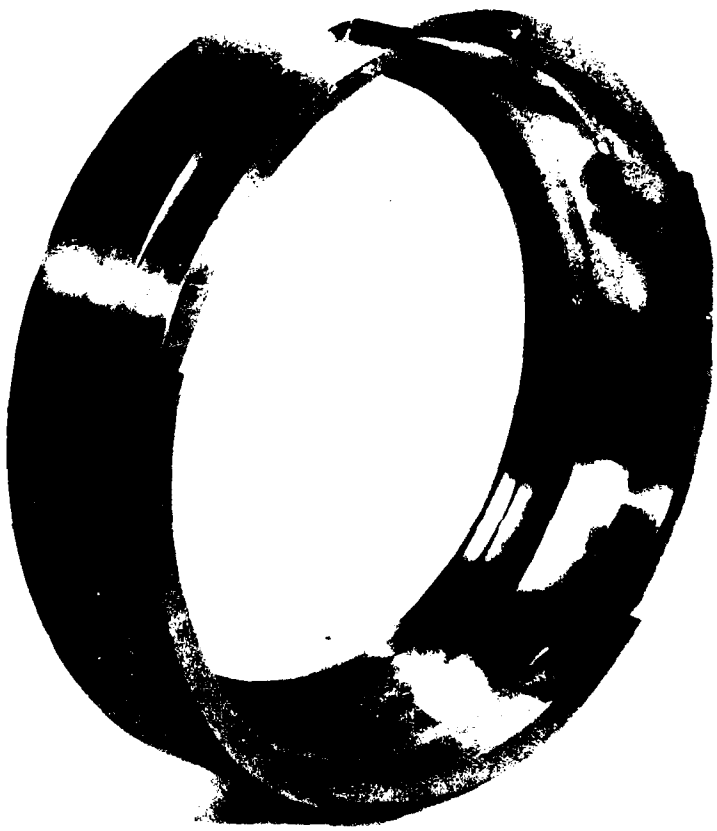

Figure 3 - Diffuser Ring Alone

Figure 4 - Assembled Pump Casing and Diffuser Ring

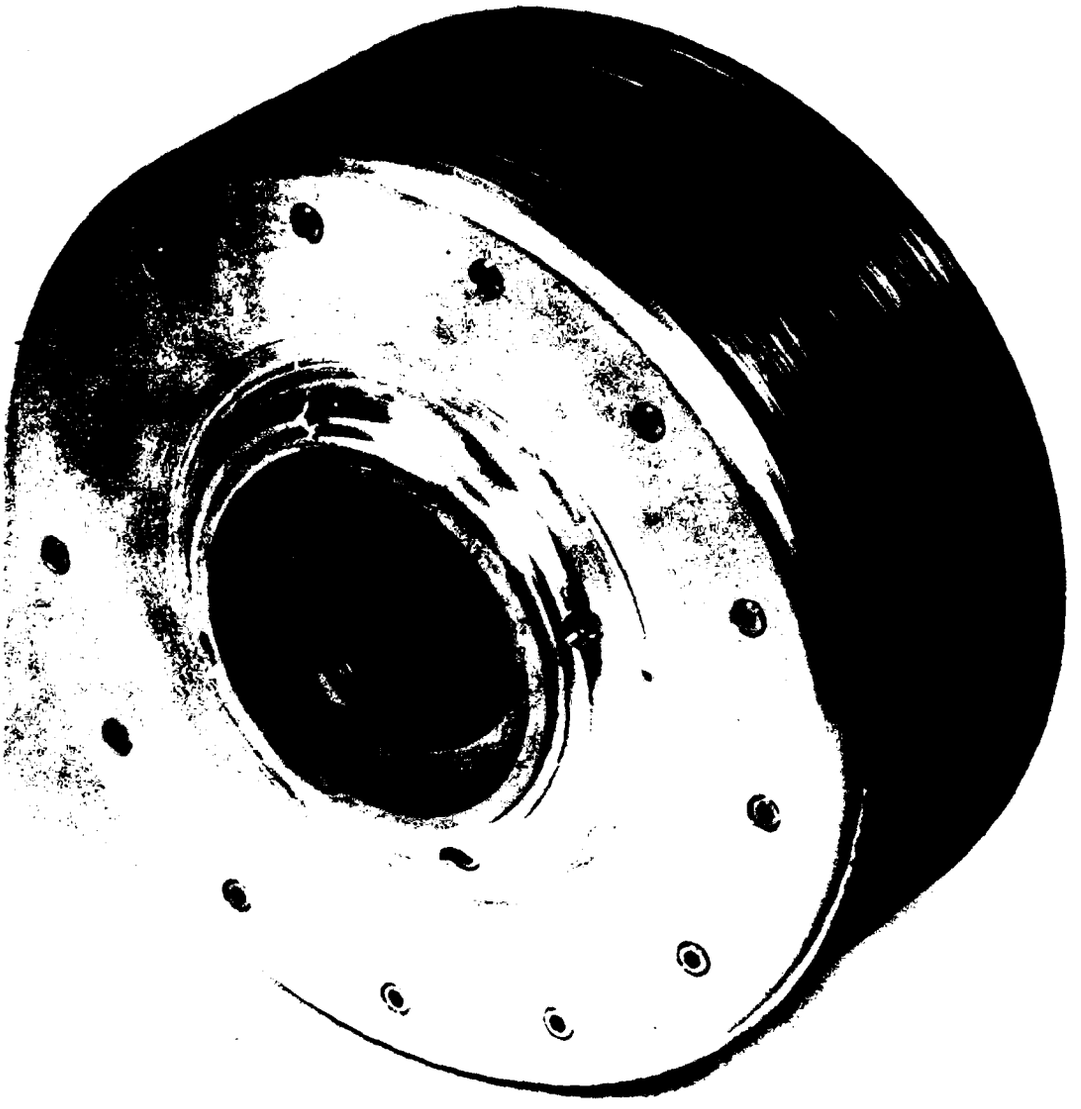

Figure 5 - 6-In. Rotor with Flat End Plates

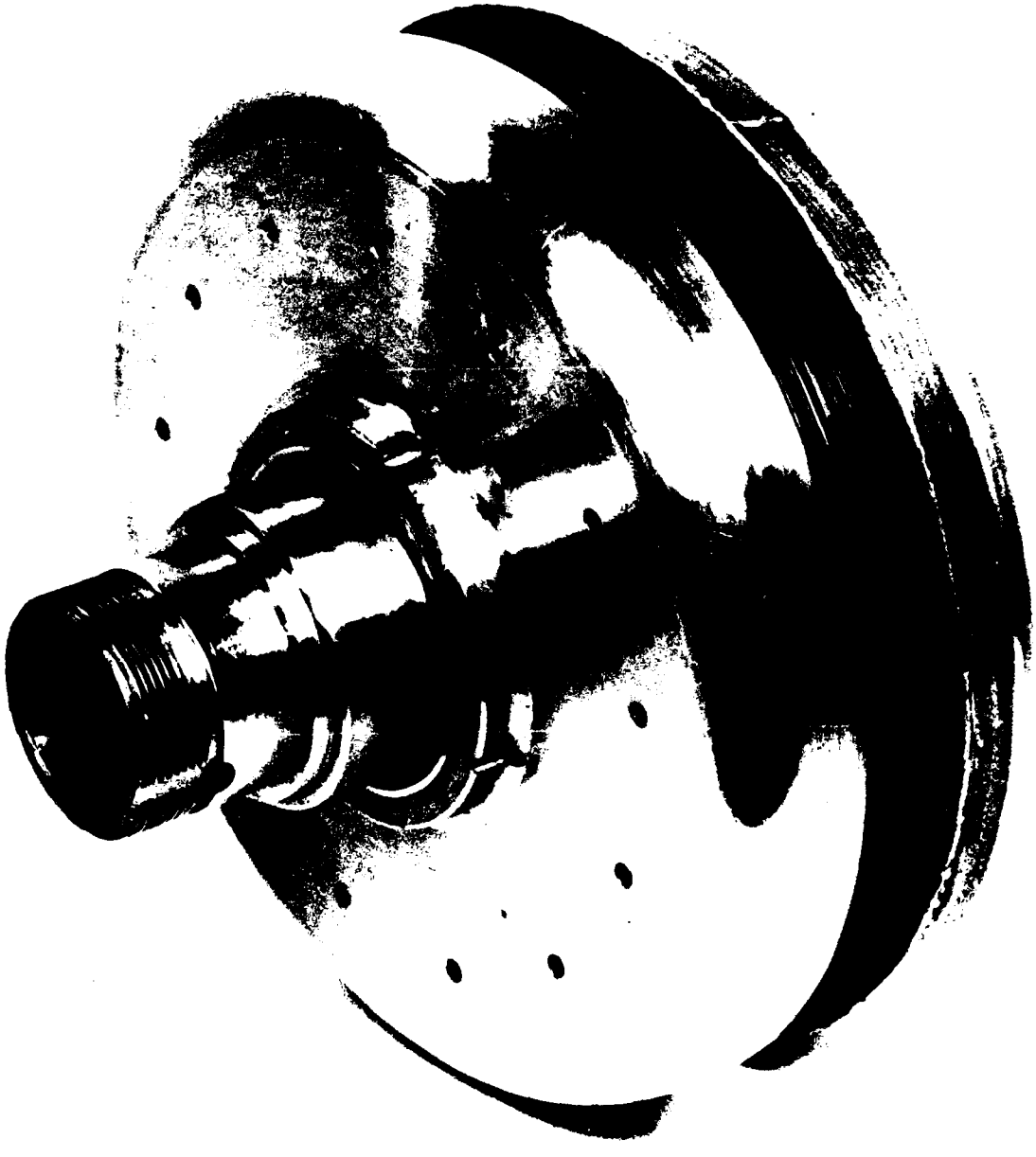

Figure 6 - 6-In.-Diam Rotor with Cupped End Plates

Figure 7a, and for disks having artificially roughened surfaces, as shown in Figure 7b. Surface roughening was achieved by machining 0.03-in. (0.8-mm)-wide radial grooves to a nominal 0.015-in. (0.4-mm) depth in both disk faces.

PUMPING SYSTEM

The pump system shown in Figure 8 consists of a closed piping circuit, variable-speed pump driver, appropriate throttling valves for control of pump differential pressure, a heat exchanger to control fluid temperature, and appropriate vents. Pressure gages were installed to monitor both the pump inlet and pump discharge pressures. Flow rate was measured using a turbine flow meter, and temperature was monitored using a thermocouple. Pertinent instrumentation descriptions and accuracies are listed in Table 1.

A variable-speed pump drive was provided with an operating capability of 1700 to 10,000 rpm. The drive consisted of an electric motor with a mechanical variable-ratio transmission and a speed increaser gear box coupled to the disk pump through a speed and torque measuring transducer.

Static and total pressure near the pump rotor OD were measured by means of a pitot-static probe installed through the pump casing at a point approximately 0.38 in. (9.6 mm) from the rotor disk pack center line. The pitot was aligned tangential to the rotor OD and parallel to the rotor disks, with the pitot tip (total pressure tap) being from 0.06 to 0.12 in. (1.5 to 3 mm) from the disk-rotor OD. Static and total pressures near the rotor inlet were determined from a static pressure tap in the pump suction pipe and from flow velocity calculations at the pump inlet.

OPERATING PROCEDURES

All data runs were accomplished using identical procedures. Initially, the piping was filled with fluid and vented of all entrapped air. Slight deaeration was then accomplished by operating the pump with the fluid temperature elevated to 165°F (74°C) for a minimum of 15 min at near-ambient pressure. With deaeration and venting completed, fluid

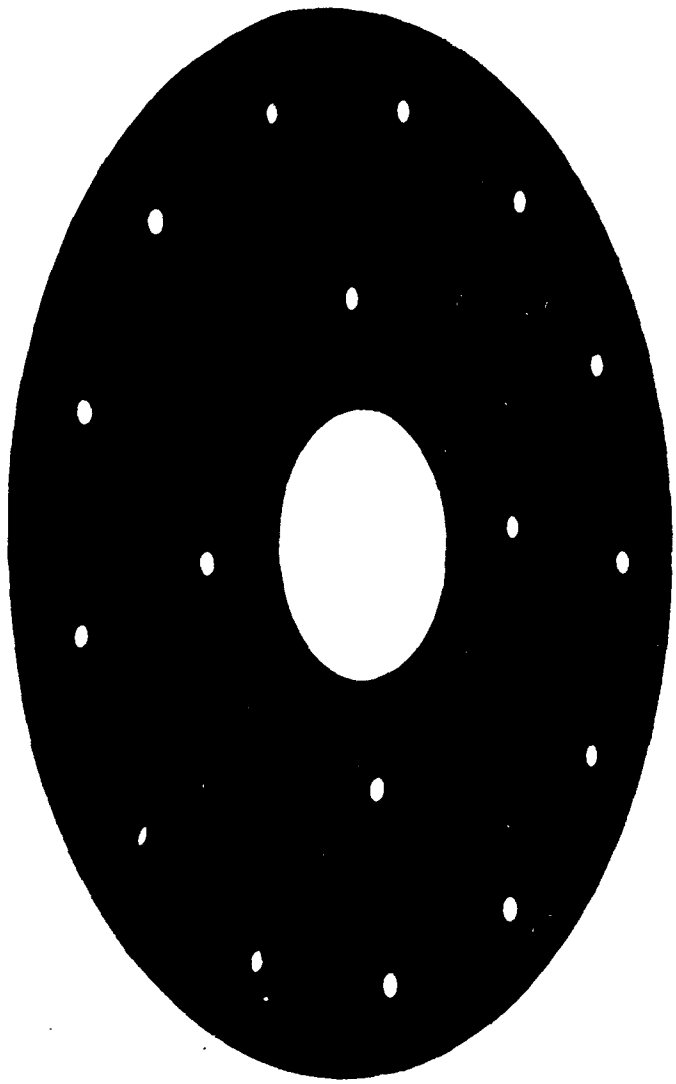

Figure 7a - Smooth Surface

Figure 7 - Rotor Disk Having (a) a Smooth Surface and (b) a Rough Surface. Each Disk Shown Has an OD of 5.94 In. and an ID of 1.5 In.

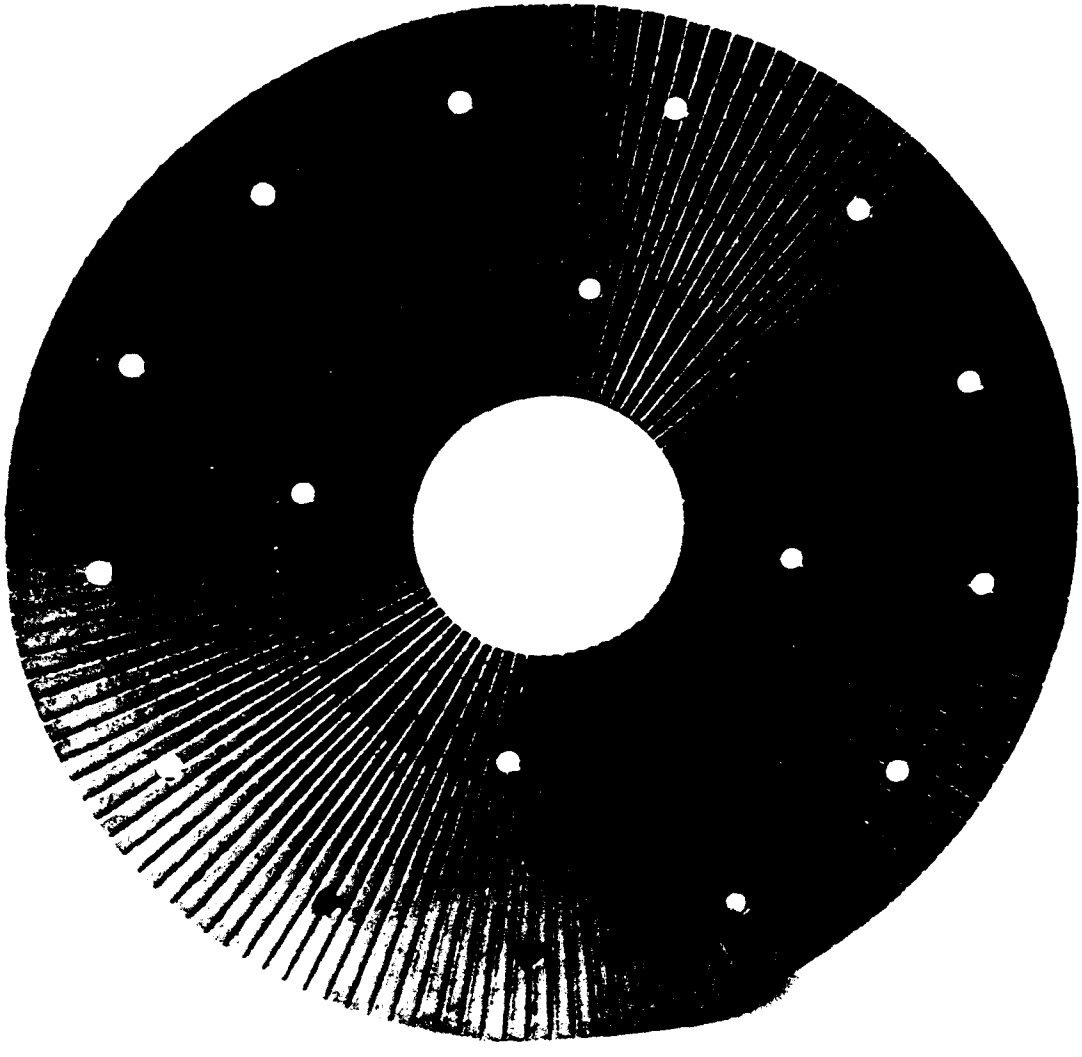

Figure 7b - Rough Surface

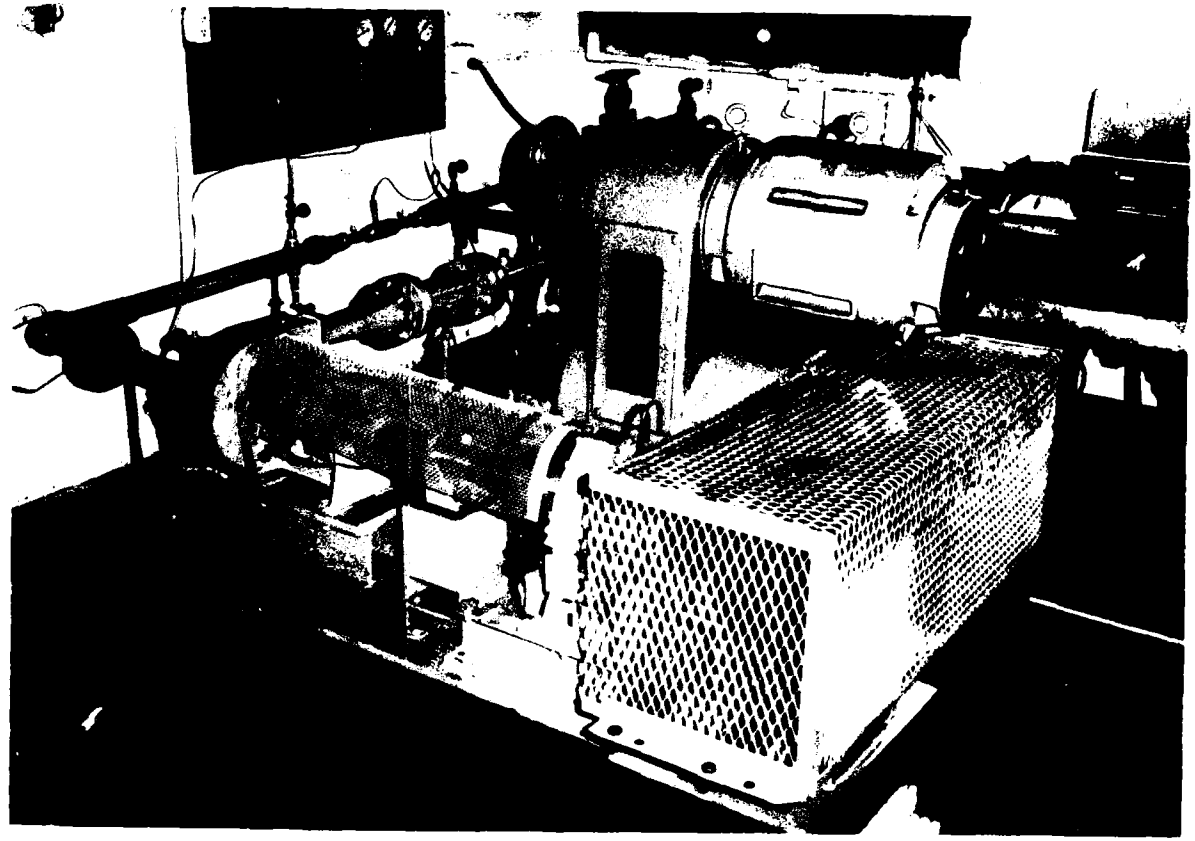

Figure 8 - Test Loop with 10-In.-Rotor Pump Installed

TABLE 1 - PUMP SYSTEM INSTRUMENTATION AND ACCURACIES

Measured Quantity	Measuring Instrument and Description	Estimated Uncertainty
Shaft Speed and Torque	S. Himmelstein and Co. torquemeter, model MCRT-2-04T, 500 in.-lb capacity with Sanborn model 311A transducer amplifier-indicator and Vishay Ellis model V/E 13 digital indicator	±1%
Flow Rate	Flow Technology, Inc., model FT-32-M225 LJ, with John Fluke, Inc., digital counter-timer, model 1925A	±1%
Temperature	Copper-constantan thermocouple with Doric Scientific digital indicator, model 412A	±3 degrees
Pump Discharge Pressure	Marshaltown gage, 0-400 psig	±5 psig
Pump Suction Pressure	0-6 ft water manometer or Weksler Instrument Co. gage, 0-30 psig	±1 in. ±1 psig
Rotor Static Pressure and Rotor Total Pressure	United Sensor and Control Corp. pitot static probe No. PDB-8-F6-ML with Weksler Instrument Co. gage 0-200 psig for static pressure and Ashcroft gage 0-600 psig for total pressure	±5 psig ±10 psig

temperature was brought down to the desired level through adjustment of cooling water flow through the heat exchanger. For each run, flow rate was adjusted from zero to full flow in 10 to 20-gpm (37.9 to 75.7-ℓ/min) increments by adjusting throttle valves. Speed and temperature were maintained through adjustment of cooling water and driver controls as required. Torque, temperature, flow rate, pump suction, and discharge pressures and static and total pressures near the rotor OD were recorded. These give sufficient data to define pump overall performance.

PUMP PARAMETERS MEASURED

The disk-rotor-pump design variables investigated are listed in Table 2, along with the ranges or values investigated. The actual pump performance parameters measured are listed in Table 3.

TABLE 2 - INDEPENDENT PUMP DESIGN VARIABLES INVESTIGATED

Variable Notation	Definition of Variable	Values Investigated	
		10.0-In.-OD Rotor	5.94-In.-OD Rotor
h	Spacing between adjacent disks (in.)	0.006, 0.010	0.006, 0.0088, 0.0176, 0.035, 0.070, 0.14, 0.26
t	Disk thickness (in.)	0.005, 0.020	0.005, 0.031
r_o	Disk outer radius (in.)	5.0	2.97
r_i	Disk inner radius (in.)	1.25	0.5, 0.75
ω	Rotor angular velocity (radians/sec)	4.67, 7.96, 9.42	9.42, 13.26, 15.92, 18.57
Q	Total flow rate through pump (gpm)	0 thru 120	0 thru 130
P_i	Static pressure at rotor inlet (psig)	2 (nominal)	2 (nominal), 50 (nominal)
ρ	Fluid density (lbm/ft^3)	62.12 (water)	62.12-61.55 (water) 68.88-68.25 (ethylene glycol)
u	Fluid dynamic viscosity ($lbf\text{-}sec/ft^2$)	1.58×10^{-5} (water)	1.58×10^{-5}, 1.07×10^{-5} (water) 2.78×10^{-4}, 1.27×10^{-4} (ethylene glycol)
T	Fluid temperature (^oC)	32 (nominal)	32, 55 (nominal)

TABLE 3 - PUMP PERFORMANCE
PARAMETERS MEASURED

Pump Parameter	Parameter Definition
τ	Shaft torque (in.-lb)
P_t	Stagnation pressure rise through rotor (psi)
P_s	Static pressure rise through rotor (psi)
P_{diff}	Differential pressure across pump (psi)

RESULTS

Considerable data were collected on disk-rotor performance. All data presented is an average of a minimum of two runs. Performance data for initial operation with the 10-in. (254-mm)-diameter rotor pump is presented in Tables 4 and 5. The 10-in. pump was capable of producing a flow rate of 100 gpm (378.6 ℓ/min) at 150 psig (10.5 kg/cm^2) when operating at 3550 rpm. As shown in Tables 4 and 5, pump overall efficiencies ranged from 29.8 to 34.9%, and observed rotor efficiency varied from 57.1 to 66.2% for the various operating conditions.

A much more thorough investigation was conducted with the more versatile 5.94-in. (151-mm) rotor pump. This unit, using a 4:1 radius ratio rotor with smooth disks, was capable of producing flow rates of 80 gpm (303 ℓ/min), at pressures up to 225 psig (15.8 kg/cm^2) at pump best efficiency point when operating at 7000 rpm on water. Pump overall efficiencies ranged from 27 to 41%, while observed rotor efficiencies were 52 to 66%. Complete performance data are listed in Tables 6 through 48 for the various rotors evaluated. Certain performance parameters for the various rotors are graphed in Figures 9-18. All data were taken under identical conditions using the same pump casing and piping system.

TABLE 4 - PERFORMANCE OF DISK PUMP WITH VOLUTE CASING AND 10-IN. ROTOR FOR DISK SPACING OF 0.006 IN.

Temperature (°C)	Speed (rpm)	Flow (gpm)	Pressure Rise Across Pump (psi)	Rotor Discharge Pressure (psig)		Shaft Power (bhp)	Efficiency (%)	
				Static	Total		Overall Pump	Rotor Transfer
29	1760	0	49.5	36	58	2.1	0	0
29	1760	25	45	30	57	2.8	23.4	33.8
29.5	1760	35	41	28	55.5	3.1	27.0	40.7
30	1760	45	37.5	25.5	54.5	3.3	29.8	47.7
29.5	1760	55	32	24	57	3.6	28.5	55.3
29.5	1760	65	29.5	21.5	55	3.9	28.7	59.5
29.5	1760	75	24.5	19	54.5	4.3	24.9	58.8
29.5	1760	85	20	18.5	55	4.6	21.5	62.4
29	1760	95.5	16	18.5	53.5	5.0	17.8	62.1
32	3550	0	204	135	228	18	0	0
33.5	3550	21	195	123.5	222.5	19.7	12.1	18.7
36	3550	40	188	112	220	21.4	20.5	31.4
38.5	3550	60	176	102.5	216	23.2	26.5	41.6
40	3550	80	165.5	194.5	212	25.5	30.3	48.3
41	3550	100	150	83.5	205.5	27.2	32.2	51.3
44	3550	120	122	66	190	28.2	30.5	57.1

Rotor Design Parameters

Suction pressure - 2 psig
OD - 10.0 in.
ID - 2.5 in.
Disk thickness - 0.005 in.
No. of disks - 170
Pumped fluid - tap water

TABLE 5 - PERFORMANCE OF DISK PUMP WITH VOLUTE CASING AND 10-IN. ROTOR FOR DISK SPACING OF 0.010 IN.

Temperature (°C)	Speed (rpm)	Flow (gpm)	Pressure Rise Across Pump (psi)	Rotor Discharge Pressure (psig)		Shaft Power (bhp)	Efficiency (%)	
				Static	Total		Overall Pump	Rotor Transfer
35	1760	0	53	41	55	2.8	0	0
32	1760	30	47	30	55	3.2	35.6	32.6
32	1760	40	44	28	56	3.4	30.5	41.9
32	1760	50	40	25	55	3.5	33.7	49.1
32	1760	60	36	23	51	3.8	33.7	49.6
31	1760	70	33	21	53	4.2	31.7	53.8
30	1760	80	26	19	53	4.5	26.9	57.6
30	1760	90	18	17	52	4.8	19.8	60
36	3000	0	149	118	160	11.4	0	0
36	3000	21	146	99	157	12.1	14.9	20.6
38	3000	41	136	85	155	12.8	25.1	36.1
39	3000	60	130	78	157	14	32.3	48
40	3000	80	117	67	153	15.7	34.9	54.7
42	3000	100	101	59	151	17.1	34.5	61
43	3000	120	85	53	148	18.6	32.2	65.4
32	3600	0	219	168	253	19.4	0	0
38	3600	22	210	143	268	20.6	12.8	21.7
43	3600	40	200	127	267	21.7	21.6	37.5
49	3600	60	188	114	274	22.8	28.9	54
52	3600	80	176	98	273	25.1	32.8	63.5
54	3600	100	126	58	240	26.8	27.5	64.4
55	3600	120	99	33	223	28.6	24.1	66.2

Rotor Design Parameters

Suction pressure - 2 psig
Rotor OD - 10.0 in.
Rotor ID - 2.5 in.
Disk thickness - 0.020 in.
No. of disks - 59
No. of through pins (outer bolt circle - 6
(inner bolt circle - 4
Pumped fluid - tap water

TABLE 6 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.006-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	53.5	0	70	52	81	2.7	0.0	0.0
	53.0	10	67	49	79	3.0	21.4	13.1
	53.2	20	63	45	76	3.3	35.5	22.1
	53.2	30	60	42	73	3.8	42.4	27.4
	53.1	40	55	40	71	4.2	49.4	30.8
	53.0	50	47	39	69	4.6	53.6	30.1
	53.0	60	34	38	68	5.0	57.2	24.0
	52.9	71	8	37	68	5.5	59.6	6.0
5000	55.4	0	140	105	158	6.6	0.0	0.0
	53.7	10	133	100	153	7.1	17.5	10.9
	53.9	20	128	94	152	7.7	31.3	19.4
	54.9	30	125	90	147	8.6	39.3	25.5
	54.4	40	121	86	144	8.9	49.0	31.8
	54.2	50	115	84	140	10.2	49.7	32.8
	54.0	60	106	81	138	11.0	53.5	33.7
	53.5	70	92	78	135	11.7	56.6	32.0
	52.6	80	74	77	133	12.9	57.1	26.9
	50.9	90	13	75	131	13.6	59.4	5.0
6000	55.1	0	204	154	238	10.4	0.0	0.0
	53.9	20	186	135	218	12.0	29.3	18.1
	54.4	40	175	125	205	13.7	46.0	29.8
	54.7	60	163	118	198	16.6	52.2	34.4
	54.4	80	137	113	191	18.2	59.8	35.2
	53.8	100	67	109	187	20.9	61.7	18.8
	54.5	104	19	108	187	21.5	61.8	5.4
7000	54.2	0	273	205	304	15.7	0.0	0.0
	53.0	20	250	185	290	17.6	26.5	16.6
	53.5	40	240	173	280	20.8	40.8	27.0
	54.1	60	228	163	270	23.2	51.2	34.4
	54.7	80	208	157	264	27.0	55.4	36.0
	53.7	100	168	151	258	29.9	59.6	32.8
	52.5	119	27	148	254	32.8	62.6	5.7

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 7 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.006-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	52.9	0	70	54	84	2.8	0.0	0.0
	52.2	10	69	54	84	3.6	21.9	11.3
	52.3	20	68	51	83	3.8	38.3	20.7
	52.3	30	64	48	80	4.3	46.9	26.2
	52.2	40	59	46	78	4.8	51.2	28.4
	52.2	50	49	44	77	5.2	56.8	27.3
	52.2	60	36	42	74	5.8	57.9	21.9
	52.8	70	5	40	73	6.4	56.9	3.2
5000	55.6	0	147	114	170	7.4	0.0	0.0
	53.7	10	143	110	167	7.7	21.0	10.8
	54.6	20	138	104	163	8.7	33.4	18.5
	54.5	30	134	99	159	9.6	42.4	24.4
	54.0	40	130	95	157	10.3	50.3	29.4
	53.5	50	122	91	152	11.4	52.8	31.1
	54.1	60	112	89	148	12.0	57.8	32.7
	54.4	70	100	87	147	13.1	59.5	31.2
	53.2	80	78	85	143	14.3	59.2	25.5
	52.8	90	12	82	141	15.1	61.0	4.2
6000	56.0	0	210	161	238	13.1	0.0	0.0
	53.6	20	197	147	233	13.9	29.3	16.5
	53.8	40	186	135	221	16.5	43.4	26.3
	54.6	60	173	129	214	18.7	53.1	32.5
	55.2	80	143	121	205	21.3	57.0	31.3
	54.7	100	53	117	201	24.3	59.1	12.7
	54.8	102	16	116	201	24.7	58.8	3.8
7000	57.7	0	288	219	328	17.1	0.0	0.0
	53.8	20	274	205	328	20.5	25.7	15.6
	54.4	40	257	187	301	23.5	40.5	25.5
	54.4	60	243	176	291	27.4	47.9	31.0
	53.8	80	220	168	283	30.2	55.0	34.0
	54.8	100	176	164	277	34.1	57.6	30.1
	56.2	116	24	159	272	37.2	58.9	4.4

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 8 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.006-IN. SPACING, 6:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	53.9	0	71	53	81	2.5	0.0	0.0
	53.3	10	67	49	78	2.8	23.6	14.2
	53.1	20	62	44	75	3.0	39.6	23.8
	52.8	30	60	42	72	3.6	46.2	29.6
	52.4	40	55	40	70	4.1	49.5	31.2
	52.4	50	46	38	67	4.4	54.5	30.5
	51.9	60	33	36	66	5.0	54.8	23.0
	52.0	70	5	33	64	5.5	55.9	3.7
5000	53.0	0	143	107	161	5.8	0.0	0.0
	51.9	10	136	100	154	6.7	19.1	11.8
	52.0	20	129	93	151	7.5	32.5	20.2
	52.6	30	123	88	145	8.2	41.3	26.3
	53.4	40	120	84	140	8.6	49.7	32.4
	53.1	50	116	83	139	9.5	54.0	35.5
	52.4	60	107	80	137	10.5	56.7	35.8
	52.5	70	92	77	133	11.7	56.2	32.2
	52.6	80	74	74	130	12.2	59.3	28.3
	52.3	91	7	72	128	13.2	60.7	2.8
6000	54.9	0	207	153	229	9.8	0.0	0.0
	51.9	20	185	134	215	12.1	28.6	17.9
	51.6	40	176	124	205	13.9	45.1	29.6
	51.6	60	163	117	197	16.3	53.1	35.0
	56.4	80	139	112	191	18.6	58.3	34.9
	55.8	100	127	105	186	21.3	59.7	34.7
	56.8	106	19	104	185	21.5	62.3	5.5
7000	55.8	0	281	209	311	15.2	0.0	0.0
	51.4	20	253	185	291	17.8	26.1	16.6
	50.6	40	243	173	282	20.7	41.4	27.4
	51.3	60	234	165	275	23.0	52.8	35.6
	51.0	80	212	158	267	26.9	56.3	36.8
	53.1	100	171	149	257	29.9	59.4	33.4
	55.8	120	25	143	251	33.3	61.2	5.2

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.0 in.
Disk thickness - 0.005 in.

TABLE 9 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.006-IN. SPACING, 6:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	53.2	0	75	57	87	2.7	0.0	0.0
	51.9	10	71	53	84	3.3	25.1	12.7
	52.4	20	68	58	80	3.6	40.6	22.0
	53.0	30	63	44	76	4.4	42.8	25.1
	53.6	40	57	42	74	4.6	51.7	28.8
	54.0	50	49	41	72	5.0	56.1	28.5
	53.6	60	35	38	70	5.8	54.6	21.3
	53.2	69	6	36	69	6.0	58.2	4.0
5000	53.9	0	153	117	173	7.9	0.0	0.0
	53.0	10	148	111	170	8.2	19.1	10.5
	52.6	20	139	102	173	8.5	35.1	19.1
	53.8	30	136	98	159	9.8	40.9	24.2
	51.8	40	131	93	155	10.6	47.8	28.8
	54.5	50	124	90	152	11.4	52.7	31.7
	54.4	60	117	87	148	12.4	55.3	33.1
	54.5	70	98	84	144	13.3	56.9	30.0
	53.6	80	79	82	143	14.8	56.8	25.0
	52.6	89	15	79	139	15.3	58.7	5.1
6000	56.8	0	219	162	245	11.7	0.0	0.0
	52.6	20	202	146	234	14.1	28.9	16.7
	52.8	40	191	136	223	16.4	44.2	27.2
	54.1	60	179	129	217	19.0	52.5	32.9
	55.0	80	148	122	207	21.5	56.9	32.1
	53.8	100	60	115	200	24.3	58.8	14.4
	53.9	102	20	114	198	24.3	59.4	4.9
7000	57.6	0	300	225	336	18.3	0.0	0.0
	53.0	20	280	207	323	21.3	25.0	15.3
	52.3	40	263	189	307	24.9	38.5	24.7
	53.2	60	251	178	297	27.9	48.0	31.5
	54.2	80	225	169	287	31.8	52.3	33.1
	54.0	100	185	162	280	34.6	57.1	31.1
	55.0	115	26	157	275	37.9	57.9	4.6

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.0 in.
Disk thickness - 0.005 in.

TABLE 10 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.0088-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	53.4	0	71	52	77	1.9	0.0	0.0
	53.9	10	66	47	74	2.2	30.6	17.1
	54.0	20	64	44	72	2.6	46.4	28.2
	54.0	30	64	43	71	3.0	57.6	37.5
	53.9	40	61	41	69	3.4	63.0	42.1
	54.1	50	55	40	68	3.9	63.4	40.7
	54.2	60	39	39	66	4.3	66.5	31.9
	54.4	64	9	33	61	4.5	61.4	7.5
5000	56.0	0	134	104	154	5.6	0.0	0.0
	53.7	10	123	92	144	6.4	19.5	11.3
	53.6	20	122	89	142	7.1	32.4	19.9
	53.6	30	119	86	140	7.9	41.5	26.2
	53.8	40	118	85	139	8.6	49.0	31.8
	54.2	50	116	83	137	9.5	53.2	35.5
	54.5	60	109	80	134	10.3	56.5	37.0
	54.6	70	101	79	132	11.1	59.2	37.1
	54.7	80	82	77	130	11.9	61.2	32.2
	54.4	86	15	68	125	12.7	58.6	5.9
6000	53.0	0	201	151	225	10.5	0.0	0.0
	53.3	10	184	136	209	11.0	16.0	9.8
	53.8	20	179	128	204	11.6	28.7	18.0
	54.4	30	176	124	201	12.8	37.2	24.2
	54.9	40	172	121	199	14.0	43.4	28.7
	54.8	50	171	119	197	15.1	48.5	33.0
	54.9	60	167	117	194	16.2	52.6	36.1
	54.8	70	160	114	192	17.3	55.8	37.7
	55.0	80	149	113	189	18.7	57.3	37.3
	54.1	90	127	110	185	19.8	58.7	33.7
	53.5	100	81	108	184	20.9	60.4	22.6
	54.2	105	20	107	185	21.7	61.1	5.6
7000	57.0	0	266	199	296	16.4	0.0	0.0
	53.0	10	252	186	284	17.1	13.4	8.6
	53.6	20	246	181	280	18.3	24.1	15.7
	54.0	30	242	173	274	20.0	31.5	21.2
	54.5	40	237	168	271	21.1	38.7	26.2
	54.7	50	234	165	268	22.2	44.8	30.7
	54.8	60	233	161	266	24.0	48.4	34.0
	54.8	70	227	158	263	25.6	51.6	36.3
	54.0	80	218	155	259	27.5	53.0	36.9
	54.0	90	206	152	255	28.9	55.4	37.4
	54.2	100	185	150	252	30.9	56.0	35.0
	54.3	110	144	148	251	32.2	58.3	28.7
	54.3	120	67	146	250	33.5	60.4	14.1

Suction pressure - 1 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 11 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.0088-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	53.4	0	73	58	85	2.7	0.0	0.0
	52.7	10	62	45	70	2.8	28.2	13.1
	53.1	20	59	41	68	2.9	48.8	23.5
	53.5	30	56	37	66	4.0	42.5	24.5
	53.3	40	55	37	66	4.6	46.9	28.1
	53.6	50	51	37	67	5.2	49.9	28.7
	52.9	60	18	37	67	5.8	52.3	11.0
5000	54.0	0	147	116	172	7.9	0.0	0.0
	53.6	10	129	99	152	8.7	15.6	8.6
	53.8	20	125	89	148	9.52	26.6	15.3
	54.0	30	125	88	150	10.31	36.1	21.2
	54.6	40	131	98	157	11.42	43.6	26.8
	54.8	50	132	100	160	12.69	48.2	30.3
	54.5	60	119	91	149	13.65	49.0	30.5
	55.0	70	114	91	150	14.7	52.4	31.7
	53.8	80	98	94	154	15.6	57.3	29.4
	55.8	82	16	76	137	16.1	49.9	4.7
6000	56.0	0	208	163	240	12.8	0.0	0.0
	53.3	10	193	146	224	14.0	13.9	8.0
	53.4	20	192	145	225	15.0	25.2	14.9
	53.6	30	196	146	229	16.2	34.6	21.2
	53.8	40	197	147	231	17.8	40.8	25.8
	54.3	50	201	149	234	19.0	47.2	30.8
	54.7	60	196	145	231	20.8	49.9	33.1
	54.8	70	187	141	227	22.0	53.2	34.7
	54.9	80	178	139	224	23.6	54.8	35.2
	54.8	90	161	136	220	24.8	57.1	34.2
	54.8	100	81	132	217	26.3	57.9	18.0
	56.7	102	24	129	216	26.8	57.2	5.3
7000	56.5	0	298	226	331	20.0	0.0	0.0
	51.9	10	290	216	328	22.4	11.8	7.5
	52.0	20	283	216	324	23.6	21.9	14.0
	51.6	30	280	211	320	25.4	29.2	19.3
	51.1	40	277	204	318	26.9	36.1	24.0
	51.0	50	275	199	315	28.8	40.9	27.9
	52.7	60	268	197	313	31.1	44.1	30.2
	54.0	70	260	191	308	32.8	47.3	32.4
	53.6	80	250	188	303	34.5	49.9	33.8
	54.2	90	238	186	299	36.5	51.7	34.2
	55.0	100	221	182	294	38.0	53.6	33.9
	56.1	110	175	179	292	40.0	54.9	28.1
	56.7	119	30	181	294	40.0	59.7	5.2

Suction pressure - 1 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 12 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.0176-IN. SPACING
4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.3	0	73	51	80	2.0	0.0	0.0
	31.7	10	70	47	77	2.4	29.4	17.3
	32.0	20	67	44	74	2.7	46.2	28.9
	32.0	30	64	42	72	3.0	57.0	36.8
	31.8	40	61	40	70	3.6	59.9	40.1
	32.0	50	56	38	68	4.0	62.2	40.8
	32.3	60	43	37	67	4.5	63.4	33.4
	32.0	65	9	37	67	4.6	66.6	7.4
5000	34.0	0	142	104	157	6.2	0.0	0.0
	32.1	10	134	96	149	6.5	19.5	12.0
	31.9	20	129	91	144	7.1	32.9	21.1
	31.6	30	126	81	132	7.9	39.1	27.8
	31.5	40	124	78	139	8.9	47.2	32.6
	31.6	50	119	81	136	9.7	51.8	35.9
	31.6	60	113	79	134	10.6	54.4	37.2
	31.8	70	104	77	132	11.7	55.8	36.4
	32.1	80	84	75	131	12.5	58.0	31.3
	32.0	86	14	74	129	12.8	59.6	5.5
6000	36.0	0	20	149	223	10.7	0.0	0.0
	32.3	10	137	138	213	11.6	15.0	6.9
	33.4	20	156	131	208	12.5	26.5	14.6
	33.9	30	166	125	206	13.5	35.3	21.5
	34.4	40	171	123	202	14.6	41.8	27.4
	34.8	50	176	119	198	15.6	46.9	32.9
	35.0	60	179	116	195	17.0	50.0	37.0
	35.1	70	182	114	193	18.1	53.2	41.1
	33.7	80	156	113	190	19.3	55.2	37.7
	34.7	90	137	109	187	20.5	57.1	35.1
	35.0	102	20	107	185	21.9	58.7	5.4
7000	35.8	0	277	202	302	17.1	0.0	0.0
	31.8	10	266	192	294	18.9	12.2	8.2
	32.2	20	255	176	285	18.9	23.6	15.8
	31.2	30	253	175	283	20.0	32.5	22.2
	36.2	40	243	167	276	21.7	38.1	26.2
	36.1	50	240	164	270	22.9	43.4	30.6
	35.0	60	236	162	268	24.2	48.2	34.1
	33.8	70	232	158	264	25.7	51.5	36.9
	32.7	80	225	155	262	27.5	53.6	38.1
	35.7	90	205	151	257	30.0	53.4	35.9
	34.9	100	190	150	256	31.4	55.7	35.3
	36.2	110	151	147	253	33.5	56.1	28.9
	35.4	115	25	146	250	33.5	57.9	5.0

Suction pressure - 1 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 13 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.0176-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	33.4	0	79	56	88	3.3	0.0	0.0
	32.8	10	78	54	86	3.6	24.0	12.8
	32.9	20	77	52	85	4.0	39.0	22.5
	32.7	30	75	50	83	4.5	47.5	29.1
	32.6	40	71	48	82	5.1	52.8	32.7
	32.4	50	64	46	80	5.6	55.6	33.1
	31.7	60	52	44	78	6.2	57.3	29.4
	30.0	66	11	44	78	6.4	60.3	6.6
5000	32.9	0	156	114	173	7.9	0.0	0.0
	32.0	10	151	110	170	8.7	18.4	10.1
	31.9	20	150	106	170	9.5	32.0	18.4
	31.6	30	146	101	165	10.3	41.3	24.8
	31.9	40	141	98	161	11.3	47.2	29.2
	31.6	50	138	95	158	12.2	51.8	33.0
	31.6	60	131	93	156	13.2	54.9	34.6
	31.3	70	122	90	155	14.3	57.6	34.9
	30.8	80	105	88	152	15.2	59.4	32.2
	28.7	87	17	88	153	15.9	61.9	5.4
6000	38.2	0	222	163	245	13.4	0.0	0.0
	35.5	10	215	157	241	14.5	14.8	8.7
	36.1	20	210	151	237	15.6	25.9	15.7
	35.9	30	206	145	234	17.0	34.1	21.3
	35.7	40	203	141	230	17.9	41.4	26.5
	35.8	50	197	136	225	19.2	45.9	29.9
	35.2	60	193	133	222	20.8	49.1	32.6
	33.9	70	185	130	218	22.0	52.2	34.4
	33.0	80	176	128	217	23.7	54.0	34.6
	38.3	90	158	124	211	24.4	56.8	34.0
	36.8	100	86	123	210	25.9	58.0	19.4
	35.2	103	23	122	210	26.1	59.3	5.3
7000	32.6	0	301	221	335	20.3	0.0	0.0
	33.2	10	295	214	330	22.2	12.6	7.8
	32.4	20	288	206	326	23.6	22.9	14.3
	37.4	30	281	198	320	24.9	30.9	19.8
	36.4	40	278	194	316	25.6	39.4	25.4
	35.1	50	275	190	311	28.0	42.9	28.7
	32.3	60	271	188	311	30.3	46.5	31.3
	37.7	70	260	180	300	32.2	48.1	33.0
	34.8	80	249	186	298	34.4	50.4	33.8
	31.8	90	246	176	297	36.2	53.2	35.7
	37.7	100	228	170	288	36.6	55.9	36.3
	34.8	110	191	168	285	38.8	57.0	31.6
	31.8	116	30	166	285	40.2	57.7	5.1

Suction pressure - 2 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 14 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.0176-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	54.4	0	70	57	81	2.3	0.0	0.0
	53.8	10	67	53	78	2.8	23.6	14.2
	54.1	20	64	50	76	3.1	39.1	24.1
	54.1	30	62	48	74	3.5	48.5	31.1
	53.9	40	57	46	72	4.0	52.8	33.3
	53.8	50	48	45	71	4.3	58.7	32.3
	53.6	60	36	44	70	4.7	62.4	26.6
	54.0	72	7	43	68	5.4	61.9	5.4
5000	54.9	0	142	107	168	5.8	0.0	0.0
	52.6	10	135	100	154	6.2	21.7	12.7
	53.5	20	130	99	151	7.1	35.1	21.5
	53.7	30	127	96	149	8.0	43.6	27.7
	53.9	40	124	92	145	8.6	51.1	33.5
	53.6	50	120	90	144	9.6	55.4	36.5
	53.3	60	111	88	141	10.3	59.4	37.7
	53.4	70	98	86	139	11.4	60.2	35.0
	53.0	80	80	84	138	12.5	61.6	30.0
	53.3	92	16	83	139	13.6	64.0	6.3
6000	55.5	0	203	152	228	9.9	0.0	0.0
	53.4	20	188	137	217	11.9	29.5	18.4
	53.4	40	180	129	210	13.9	46.2	30.2
	53.4	60	170	122	204	16.4	54.6	36.3
	53.7	80	145	118	199	19.1	58.5	35.4
	54.0	100	88	114	195	21.6	61.7	23.8
	53.0	107	20	112	193	22.6	62.1	5.5
7000	53.7	0	278	208	311	15.6	0.0	0.0
	51.2	20	257	189	295	18.0	17.2	16.7
	51.3	40	249	179	287	20.7	42.1	28.1
	51.7	60	240	171	280	23.9	51.2	35.2
	52.4	80	219	164	274	26.9	57.8	38.0
	53.8	100	182	159	268	30.6	60.1	34.6
	52.3	122	27	155	265	34.3	63.4	5.6

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 15 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.0176-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	54.7	0	75	57	88	2.9	0.0	0.0
	53.9	10	73	56	88	3.2	26.9	13.3
	53.9	20	72	53	85	3.8	39.1	21.9
	53.8	30	69	51	83	4.2	50.4	29.0
	53.8	40	63	49	82	4.8	54.5	30.7
	53.4	50	53	47	78	5.2	57.4	29.5
	53.7	60	43	45	77	5.5	64.2	27.6
	54.0	71	8	44	76	6.3	63.0	5.3
5000	55.0	0	153	114	173	7.5	0.0	0.0
	54.4	10	148	110	170	7.9	20.3	10.9
	53.4	20	145	106	170	8.7	35.0	19.4
	54.0	30	143	102	167	9.6	44.6	26.1
	53.6	40	138	99	163	10.5	51.2	30.8
	53.1	50	133	98	161	11.7	54.4	33.3
	53.5	60	120	95	158	12.5	58.6	33.7
	54.2	70	111	94	156	13.7	59.4	33.0
	53.2	80	87	90	153	14.7	61.2	27.7
	54.2	91	16	89	151	15.6	63.8	5.5
6000	55.4	0	219	162	246	11.6	0.0	0.0
	53.6	20	208	153	241	14.1	29.7	17.2
	54.1	40	202	146	235	16.6	45.8	28.5
	54.5	60	189	137	229	18.9	55.8	34.9
	54.5	80	163	132	222	22.0	59.4	34.6
	53.8	100	97	127	218	24.8	62.4	22.8
	54.7	106	22	127	218	25.8	63.1	5.3
7000	56.3	0	300	223	336	18.2	0.0	0.0
	53.3	20	284	211	329	21.0	26.0	15.8
	53.9	40	275	198	320	24.3	41.2	26.4
	54.7	60	265	190	311	28.0	49.9	33.1
	55.2	80	246	183	306	31.8	55.7	36.1
	53.9	100	204	178	299	35.3	59.6	33.7
	53.0	119	29	173	295	39.3	61.6	5.1

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 16 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.0176-IN. SPACING, 6:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	54.6	0	72	53	82	2.5	0.0	0.0
	54.1	10	68	49	79	2.8	24.0	14.4
	54.2	20	65	46	77	3.3	36.8	23.2
	54.3	30	63	44	76	3.7	45.9	29.7
	54.4	40	57	42	73	4.1	51.7	32.4
	54.4	50	49	40	71	4.5	56.0	31.7
	54.4	60	37	38	69	4.9	58.9	26.4
	54.2	70	18	36	67	5.4	60.0	13.7
	53.7	72	7	36	68	5.5	60.4	5.3
5000	55.6	0	141	104	159	6.4	0.0	0.0
	53.3	10	135	98	153	6.6	19.6	12.0
	54.4	20	128	93	150	7.6	31.4	19.6
	54.7	30	128	91	150	8.1	43.3	27.7
	54.5	40	126	89	147	9.0	49.4	32.8
	54.8	50	120	86	146	9.9	53.9	35.3
	54.7	60	111	84	142	10.8	56.6	36.0
	54.4	70	98	82	141	11.8	58.6	33.9
	54.5	80	80	78	137	12.5	60.6	29.8
	54.3	90	46	76	136	13.3	63.0	18.1
	53.2	96	16	74	134	14.0	62.1	6.4
6000	55.7	0	202	147	238	11.3	0.0	0.0
	53.6	20	187	134	218	12.7	27.2	17.2
	53.7	40	183	129	214	15.0	42.9	28.6
	54.2	60	172	122	208	17.1	52.6	35.1
	54.9	80	145	116	203	19.8	57.3	34.2
	54.6	100	88	111	196	22.6	58.9	22.7
	55.1	108	20	109	193	23.4	60.0	5.4
7000	57.0	0	272	196	306	17.9	0.0	0.0
	53.7	20	258	185	300	19.3	24.1	15.6
	54.2	40	250	175	292	22.4	38.6	26.0
	54.1	60	240	168	286	25.7	47.9	32.7
	54.9	80	217	162	279	29.8	52.0	34.0
	54.8	100	178	156	272	32.6	56.6	31.8
	54.4	120	91	151	268	35.6	60.4	17.9
	54.0	128	30	148	265	36.2	62.6	6.2

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.0 in.
Disk thickness - 0.005 in.

TABLE 17 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.0176-IN. SPACING, 6:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	54.2	0	78	61	90	3.3	0.0	0.0
	53.5	10	74	56	87	3.5	23.1	12.3
	53.7	20	71	53	84	3.9	37.8	21.3
	53.4	30	67	50	82	4.2	48.0	27.4
	53.6	40	60	48	78	4.9	50.2	28.6
	53.6	50	51	45	77	5.2	56.6	28.4
	53.6	60	36	43	74	5.6	59.3	22.4
	54.1	70	7	42	72	6.2	58.8	4.6
5000	55.0	0	154	115	175	7.1	0.0	0.0
	53.6	10	149	109	171	8.0	20.1	10.8
	53.8	20	143	103	167	8.6	34.8	19.3
	53.7	30	138	98	161	9.6	43.0	25.2
	53.6	40	135	95	158	10.2	51.2	30.8
	53.2	50	128	92	155	11.3	54.4	32.9
	52.8	60	119	90	153	12.5	56.8	33.4
	53.1	70	105	87	149	13.4	58.6	32.0
	54.0	80	84	84	148	14.3	61.2	27.4
	52.8	90	43	82	146	15.1	63.6	15.0
	52.8	93	16	82	144	15.7	61.5	5.5
6000	55.8	0	223	165	250	12.1	0.0	0.0
	53.0	20	205	148	238	13.9	29.9	17.2
	53.2	40	198	140	230	16.3	46.0	28.4
	53.0	60	185	132	221	18.9	53.9	34.2
	53.3	80	158	127	217	21.8	58.8	33.8
	53.1	100	97	119	208	24.3	61.3	23.3
	55.3	109	23	119	208	25.2	63.6	5.8
7000	57.8	0	302	224	338	18.2	0.0	0.0
	54.0	20	283	205	326	20.8	26.2	15.9
	54.7	40	270	192	312	24.6	39.6	25.7
	54.6	60	262	185	306	27.4	50.4	33.4
	54.2	80	233	176	295	31.2	55.0	34.8
	55.3	100	181	168	288	34.6	58.7	30.5
	56.0	120	67	162	283	38.5	60.8	12.2
	56.5	125	30	162	283	39.0	62.5	5.6

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 18 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.035-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	54.3	0	63	51	80	2.5	0.0	0.0
	53.8	10	58	46	76	2.6	24.5	12.8
	53.9	20	55	42	72	3.0	39.0	21.5
	53.8	30	53	40	71	3.7	42.9	25.0
	53.6	40	47	38	69	4.1	49.7	27.0
	53.5	50	39	37	67	4.4	53.6	25.6
	53.3	60	26	35	65	4.8	57.0	19.0
	53.0	69	3	35	65	5.2	58.8	2.3
5000	55.6	0	138	106	161	6.2	0.0	0.0
	53.9	10	126	96	150	6.4	19.9	11.4
	54.2	20	119	90	145	7.1	33.1	19.4
	54.0	30	116	85	141	8.1	40.7	25.1
	54.3	40	113	82	138	8.5	49.8	31.1
	53.5	50	108	81	138	9.6	53.1	32.8
	52.9	60	99	78	134	10.3	56.5	33.6
	53.0	70	86	76	132	11.3	57.7	31.0
	53.1	80	67	73	129	12.5	57.5	25.1
	53.5	90	9	72	129	13.1	61.0	3.6
6000	55.8	0	199	150	229	10.3	0.0	0.0
	53.3	20	177	130	210	11.7	29.2	17.6
	53.9	40	168	120	200	13.6	45.2	28.8
	54.2	60	157	114	195	15.9	54.1	34.6
	54.0	80	131	109	188	18.2	58.8	33.6
	53.0	100	65	105	185	20.9	60.7	18.1
	51.9	104	13	105	184	21.6	60.5	3.6
7000	56.3	0	273	204	309	14.9	0.0	0.0
	52.2	20	244	179	284	17.4	26.2	16.3
	53.2	40	234	169	276	20.7	40.5	26.4
	54.3	60	223	160	268	23.5	49.9	33.2
	55.3	80	201	158	261	26.5	55.8	35.3
	55.2	100	163	148	255	29.9	58.9	31.8
	54.2	116	22	146	252	33.0	60.1	4.5

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 19 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.035-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	54.6	0	72	55	88	3.0	0.0	0.0
	53.8	10	68	51	83	3.2	26.1	12.6
	54.2	20	65	47	82	3.6	41.3	21.0
	54.1	30	62	45	79	4.1	49.9	26.8
	53.7	40	57	44	78	4.6	54.5	28.8
	53.4	50	49	43	78	5.1	60.0	28.2
	52.7	60	33	41	75	5.5	62.7	21.1
	53.7	69	5	40	74	6.1	61.0	3.3
5000	56.6	0	150	112	173	7.2	0.0	0.0
	54.8	10	143	106	168	7.8	20.7	10.7
	54.6	20	138	102	164	8.2	36.7	19.5
	53.9	30	134	97	160	9.4	44.3	25.1
	53.4	40	131	95	159	10.3	51.0	29.6
	53.7	50	124	91	154	11.4	53.5	31.7
	54.1	60	116	89	153	12.3	57.7	33.0
	54.4	70	103	88	151	13.1	61.2	32.1
	54.2	80	83	85	149	14.2	62.1	27.3
	55.1	90	13	83	145	15.5	60.9	4.4
6000	56.6	0	218	162	249	12.5	0.0	0.0
	53.8	20	202	148	237	13.9	29.8	17.0
	54.5	40	194	140	230	16.4	45.5	27.6
	55.1	60	183	132	222	19.3	52.6	33.1
	54.8	80	155	127	216	22.0	57.8	32.9
	54.0	100	88	121	210	24.7	60.3	20.7
	53.0	105	19	121	210	26.0	59.7	4.5
7000	56.7	0	295	218	334	18.2	0.0	0.0
	53.4	20	276	202	321	21.2	25.0	15.2
	54.2	40	265	190	308	24.1	40.1	25.7
	55.1	60	255	181	302	27.4	49.7	32.5
	53.8	80	234	174	295	31.3	54.8	34.9
	55.8	100	194	168	289	35.2	57.7	32.1
	52.8	119	26	164	285	39.1	59.9	4.6

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 20 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.035-IN. SPACING, 6:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	51.9	0	76	54	82	2.3	0.0	0.0
	52.9	10	71	50	77	2.6	25.6	16.0
	52.8	20	67	44	74	2.8	43.5	27.8
	52.8	30	63	42	71	3.3	49.7	33.2
	52.7	40	58	39	70	3.8	54.2	35.3
	53.3	50	49	36	66	4.3	55.4	33.4
	54.0	60	36	34	64	4.7	57.0	26.6
	53.7	70	9	33	63	5.0	61.8	7.4
5000	54.0	0	149	107	162	6.0	0.0	0.0
	52.1	10	141	100	155	6.8	18.9	12.1
	51.6	20	134	93	149	7.3	33.0	21.4
	51.2	30	130	87	144	7.8	43.2	29.0
	51.4	40	126	80	142	8.7	49.4	33.7
	53.1	50	121	82	138	9.5	53.6	37.1
	53.9	60	111	79	135	10.5	55.8	37.1
	53.1	70	97	76	131	11.3	57.2	34.9
	53.2	80	78	74	129	12.5	57.1	29.0
	53.6	92	14	70	126	13.0	61.3	5.8
6000	54.8	0	215	155	235	13.4	0.0	0.0
	52.2	20	194	137	216	11.8	29.7	19.2
	52.6	40	185	127	206	13.5	47.0	31.9
	53.2	60	172	119	198	16.5	52.6	36.6
	53.4	80	138	112	192	18.8	57.5	34.2
	53.5	100	68	105	185	21.5	58.8	18.4
	53.8	104	18	104	185	21.9	59.9	5.0
7000	55.5	0	287	211	315	15.4	0.0	0.0
	50.9	20	261	187	294	17.8	26.4	17.1
	52.1	40	251	176	282	20.0	43.2	29.3
	52.6	60	241	166	274	23.5	51.0	35.8
	52.0	80	220	159	266	27.1	55.5	37.9
	50.4	100	168	149	258	30.4	58.3	32.2
	47.4	120	22	143	252	34.2	59.6	4.5

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.0 in.
Disk thickness - 0.005 in.

TABLE 21 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.035-IN. SPACING, 6:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	52.5	0	82	57	89	3.6	0.0	0.0
	51.6	10	77	53	85	2.9	30.8	15.3
	51.9	20	74	50	81	3.5	43.3	24.7
	53.1	30	69	45	78	3.9	52.6	31.1
	53.1	40	60	42	74	4.2	58.8	33.1
	53.1	50	51	40	72	4.8	58.9	30.7
	52.8	60	39	38	71	5.2	62.7	26.1
	52.0	70	8	31	70	5.6	66.4	5.9
5000	53.9	0	160	115	175	7.5	0.0	0.0
	51.5	10	153	109	169	7.6	21.8	11.7
	52.0	20	146	102	164	8.0	38.7	21.3
	52.3	30	142	96	158	9.0	46.2	27.5
	51.7	40	137	94	155	9.7	54.7	33.0
	50.9	50	131	89	151	10.8	57.0	35.4
	51.9	60	120	86	147	11.7	59.2	35.8
	53.6	70	106	84	144	12.7	60.8	34.1
	54.3	80	86	81	142	13.5	63.2	29.8
	52.5	90	15	79	140	14.9	61.8	5.3
6000	54.4	0	228	166	249	11.6	0.0	0.0
	51.1	20	206	146	233	13.2	31.7	18.2
	51.2	40	197	136	223	15.3	48.7	30.0
	50.4	60	184	127	214	18.3	55.0	35.2
	50.2	80	156	122	207	20.6	60.7	35.4
	50.0	100	86	116	203	23.6	62.1	21.2
	51.0	105	19	115	201	24.0	63.2	4.8
7000	56.6	0	309	227	339	16.8	0.0	0.0
	51.3	20	280	201	314	19.8	27.2	16.5
	51.0	40	268	182	302	22.9	42.5	27.3
	49.3	60	258	178	295	26.5	51.2	34.0
	51.3	80	235	171	287	30.0	56.5	36.6
	52.6	100	192	163	278	33.2	59.9	33.7
	52.4	120	24	158	274	37.0	62.1	4.5

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.0 in.
Disk thickness - 0.005 in.

TABLE 22 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.07-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.5	0	67	48	70	1.9	0.0	0.0
	32.1	10	61	42	66	2.0	32.2	17.6
	32.1	20	59	40	62	2.3	50.5	30.2
	32.0	30	53	35	58	2.9	49.1	32.6
	31.8	40	48	32	55	3.2	53.5	34.9
	31.6	50	40	31	54	3.8	53.0	31.3
	31.1	60	30	30	52	4.1	54.4	25.4
	30.5	70	12	29	50	4.5	53.9	11.3
5000	32.4	0	133	97	140	5.1	0.0	0.0
	30.9	10	123	87	132	5.7	21.0	12.6
	31.0	20	117	82	126	6.5	33.2	21.2
	31.1	30	112	76	121	7.2	41.1	27.3
	31.1	40	107	73	117	7.8	47.4	32.1
	31.0	50	101	70	114	8.6	50.4	34.4
	31.3	60	91	67	111	9.2	53.9	34.6
	31.4	70	79	66	108	10.2	53.5	31.7
	31.3	80	64	63	105	11.3	58.2	13.0
6000	35.2	0	190	143	211	9.4	0.0	0.0
	33.6	20	170	121	192	10.7	30.3	18.5
	34.2	40	158	111	177	12.6	44.3	29.2
	34.5	60	145	103	168	14.6	51.9	34.7
	34.5	80	120	98	161	16.9	55.1	33.3
	33.7	100	76	94	156	18.8	58.1	23.7
	31.8	105	18	92	155	19.8	56.8	5.7
7000	38.8	0	257	224	283	13.6	0.0	0.0
	36.2	20	231	202	261	16.3	26.5	16.6
	37.1	40	219	187	245	19.3	39.4	26.5
	37.4	60	203	175	234	21.8	48.0	32.6
	37.2	80	182	167	225	24.2	53.9	35.1
	36.5	100	148	152	217	27.3	55.7	31.6
	33.5	118	22	145	211	29.9	57.3	5.2

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 23 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.07-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.8	0	79	59	87	3.3	0.0	0.0
	32.1	20	72	51	80	3.9	38.0	21.5
	32.1	30	69	50	79	4.4	47.5	27.7
	32.1	40	63	47	77	4.9	52.1	30.4
	32.4	50	56	46	74	5.4	54.3	30.5
	32.5	60	42	43	72	5.9	56.1	24.9
	32.6	70	27	42	71	6.5	56.9	17.0
	31.6	74	10	41	70	6.9	55.8	6.6
5000	37.8	0	154	115	171	7.6	0.0	0.0
	36.2	10	148	109	165	8.2	19.7	10.6
	36.3	20	142	103	160	9.1	32.1	18.3
	36.4	30	137	98	155	10.0	40.5	24.1
	36.4	40	132	95	153	11.2	44.9	27.6
	36.7	50	126	91	149	11.9	50.2	30.9
	37.1	60	116	88	147	13.1	52.2	31.0
	37.3	70	102	86	143	13.8	55.4	30.2
	37.2	80	86	84	141	14.6	57.6	27.5
	36.4	90	55	82	138	15.6	58.7	18.5
	34.4	93	14	82	138	16.6	56.6	4.6
6000	43.0	0	218	163	243	12.3	0.0	0.0
	41.0	20	203	149	231	15.1	26.3	15.7
	40.7	40	191	136	220	17.7	39.9	25.2
	41.2	60	177	128	213	20.1	48.7	30.8
	41.4	80	148	122	204	22.8	53.0	30.4
	40.5	100	101	118	199	25.5	56.0	23.1
	36.6	106	21	118	201	26.7	56.5	4.9
7000	49.1	0	295	218	323	18.9	0.0	0.0
	45.2	20	275	202	315	22.7	22.8	14.2
	44.4	40	259	187	297	25.3	36.9	23.9
	43.6	60	247	176	290	29.4	44.4	29.4
	41.6	80	225	169	283	33.2	49.6	31.7
	38.0	100	193	166	282	37.1	53.9	30.4
	50.0	119	26	153	261	38.7	55.7	4.7

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 24 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.14-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	31.7	0	66	48	70	1.8	0.0	0.0
	31.2	10	60	44	67	2.0	34.6	17.8
	31.3	20	56	37	60	2.4	44.9	27.5
	31.1	30	51	34	56	3.0	45.9	30.5
	31.0	40	46	33	54	3.2	53.2	34.1
	30.8	50	40	33	54	3.7	53.1	31.2
	30.3	60	26	30	50	4.1	53.7	22.9
	29.9	69	9	30	49	4.5	53.0	8.5
5000	32.9	0	130	96	139	5.3	0.0	0.0
	31.5	10	119	85	131	5.7	20.7	12.2
	31.9	20	113	81	124	6.3	33.7	20.9
	31.8	30	107	75	118	6.9	42.6	27.3
	31.6	40	102	71	113	7.4	49.5	32.4
	30.9	50	96	69	111	8.3	51.2	33.6
	30.7	60	86	66	107	9.0	53.2	33.3
	30.2	70	74	65	105	9.8	55.2	31.2
	31.2	80	57	63	102	10.5	56.4	25.6
	29.0	89	14	61	101	11.6	54.6	6.3
6000	33.6	0	186	139	202	8.9	0.0	0.0
	31.5	20	164	117	184	10.6	29.6	18.2
	32.0	40	151	106	170	12.3	43.9	28.7
	32.1	60	137	100	160	14.1	51.6	33.9
	31.8	80	113	95	154	16.3	55.2	32.4
	30.6	100	50	91	150	18.2	58.0	16.2
	29.0	102	17	89	148	18.8	56.4	5.4
7000	39.1	0	251	195	277	13.4	0.0	0.0
	36.5	20	227	154	256	15.9	26.9	16.7
	37.0	40	213	151	238	17.9	42.2	27.8
	37.4	60	197	141	225	20.9	48.6	33.0
	36.7	80	175	135	216	23.4	53.9	35.0
	35.5	100	139	128	210	27.0	54.7	30.2
	30.3	117	30	125	206	29.1	57.4	7.0

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 25 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.14-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.0	0	75	55	8	3.0	0.0	0.0
	33.3	10	70	50	76	3.2	25.7	12.8
	31.6	20	66	46	73	3.9	34.3	19.7
	31.8	30	61	44	70	4.2	43.8	25.3
	31.8	40	56	41	68	4.6	50.4	28.5
	31.7	50	47	40	67	5.1	53.0	26.8
	31.1	60	34	38	65	5.6	54.9	21.7
	30.5	70	10	37	63	5.9	57.8	6.9
5000	35.5	0	146	110	161	7.3	0.0	0.0
	33.9	10	138	101	154	8.2	18.5	9.8
	33.9	20	132	95	148	9.3	28.9	16.7
	34.0	30	126	90	142	9.9	37.6	22.3
	34.0	40	121	86	137	10.8	42.8	26.3
	34.1	50	114	83	134	11.4	48.4	29.2
	34.1	60	102	81	131	12.4	50.3	29.0
	33.9	70	90	80	130	13.6	51.5	27.1
	33.2	80	70	76	127	14.6	52.3	22.5
	31.7	89	15	75	126	15.1	55.2	5.1
6000	40.6	0	207	155	229	11.6	0.0	0.0
	37.7	20	191	139	215	14.6	25.8	15.2
	37.4	40	177	127	201	16.5	40.5	25.0
	36.4	60	161	119	193	19.4	46.5	29.1
	38.1	80	131	113	185	21.5	52.0	28.6
	36.5	100	53	109	180	23.8	55.2	13.1
	33.0	102	20	109	181	24.6	54.6	4.8
7000	47.0	0	277	209	308	17.2	0.0	0.0
	43.7	20	257	195	294	21.0	23.8	14.3
	43.1	40	242	173	277	23.6	38.0	23.9
	42.3	60	226	163	264	27.9	43.4	28.4
	40.3	80	201	157	257	30.7	49.8	30.6
	38.4	100	163	150	249	34.4	52.4	27.7
	33.0	114	25	150	249	37.8	53.6	4.4

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 26 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.26-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.5	0	64	46	67	1.6	0.0	0.0
	31.8	20	53	36	56	2.3	45.2	27.4
	32.0	30	49	33	53	2.8	47.9	31.1
	32.4	40	43	32	51	3.0	54.4	33.6
	32.3	50	33	30	50	3.3	56.8	29.0
	32.1	60	21	29	46	3.8	55.2	19.6
	32.0	67	9	29	45	4.2	52.6	8.4
5000	32.6	0	125	91	133	5.1	0.0	0.0
	31.5	20	107	75	118	6.4	32.1	19.7
	32.0	40	96	66	107	7.3	47.0	30.7
	32.6	60	79	64	101	8.6	53.9	32.5
	32.4	70	66	62	100	9.6	53.4	28.1
	31.9	80	49	59	96	10.3	54.1	22.2
	30.5	86	14	59	96	11.2	52.5	6.3
6000	35.0	0	181	132	194	8.5	0.0	0.0
	33.0	40	144	100	159	11.6	44.9	29.1
	33.2	60	129	94	152	13.6	51.5	33.3
	33.1	70	117	91	147	15.3	49.8	31.2
	32.7	80	101	90	146	16.4	51.8	28.9
	31.7	90	81	87	142	17.2	53.5	24.8
	30.0	100	16	85	141	18.3	54.0	5.2
7000	40.5	0	246	181	267	13.2	0.0	0.0
	37.6	40	200	139	224	17.7	40.5	26.5
	37.7	80	162	125	205	23.0	52.4	33.0
	36.5	100	123	121	198	26.1	53.9	27.5
	34.0	110	70	119	197	27.3	55.5	16.6
	30.8	113	22	118	195	28.2	54.5	5.2

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 27 - PERFORMANCE WITH 5.94-IN.-DIAM, 0.26-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.6	0	69	50	73	2.7	0.0	0.0
	32.3	20	59	42	65	3.3	41.7	21.2
	32.1	30	54	38	60	3.8	45.8	25.2
	32.0	40	49	35	58	4.2	48.2	26.9
	32.1	50	38	35	57	4.6	52.7	24.3
	32.3	60	24	35	55	5.0	52.7	17.0
	32.6	67	9	33	53	5.3	53.0	7.0
5000	34.3	0	135	100	145	6.7	0.0	0.0
	32.9	20	123	85	132	8.3	30.6	17.2
	32.4	40	106	75	120	9.6	44.2	25.8
	32.1	60	85	70	114	11.0	52.1	27.2
	31.6	70	72	69	112	11.9	53.1	24.7
	31.2	80	50	66	109	12.7	53.8	18.5
	30.4	85	14	65	108	13.3	53.6	5.2
6000	37.9	0	194	143	210	10.0	0.0	0.0
	35.5	40	156	110	176	14.3	43.8	25.4
	35.6	60	139	103	166	16.3	51.1	29.8
	35.2	70	124	100	162	17.6	52.5	29.0
	34.6	80	108	98	157	18.6	54.2	27.1
	33.3	90	83	95	157	19.6	56.4	22.3
	31.0	98	18	94	155	20.9	55.3	4.9
7000	44.4	0	262	193	286	15.8	0.0	0.0
	41.2	40	217	151	245	20.9	40.1	24.2
	41.4	80	169	134	220	26.2	52.5	30.2
	40.4	90	151	131	216	27.7	53.9	28.6
	38.2	100	123	128	213	29.4	54.4	24.5
	33.6	110	23	127	211	31.5	54.8	4.7

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 28 - PERFORMANCE WITH CUPPED END PLATE, 0.006-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	33	0	81	57	85	2.4	0.0	0.0
	32	10	75	51	80	2.7	25.0	16.3
	32	20	74	50	81	3.1	41.2	27.8
	32	30	73	49	81	3.6	51.5	36.0
	31	40	71	48	80	4.1	58.0	41.1
	31	50	66	47	79	4.7	60.0	41.2
	31	60	54	46	77	4.1	62.8	36.9
	31	70	8	44	77	5.6	65.0	5.8
5000	34	0	160	116	169	6.4	0.0	0.0
	32	10	156	112	165	7.2	18.6	12.6
	32	20	153	110	167	8.1	32.3	22.1
	33	30	150	105	166	8.6	44.0	30.4
	33	40	147	102	164	9.8	49.1	35.0
	33	50	142	98	162	10.7	54.6	39.0
	34	60	134	96	158	11.7	57.2	40.1
	34	70	124	93	155	12.9	58.1	39.2
	35	80	108	91	152	13.3	62.6	37.8
	34	90	68	88	149	14.2	64.3	25.3
	34	94	13	88	149	14.8	64.0	4.8
6000	37	0	230	166	240	11.3	0.0	0.0
	35	20	222	159	239	12.9	29.1	20.1
	36	40	211	148	237	15.5	45.4	31.9
	37	60	202	140	229	17.9	54.8	39.4
	37	80	179	133	221	21.0	58.2	39.8
	36	100	133	128	215	23.5	61.6	33.0
	33	110	18	127	212	25.0	62.4	4.6
7000	43	0	307	199	308	16.2	0.0	0.0
	40	20	297	209	318	19.6	25.1	17.7
	41	40	288	202	323	21.9	31.7	30.7
	42	60	278	193	315	26.7	50.3	36.5
	41	80	260	184	308	29.5	58.0	41.1
	41	100	230	178	297	32.3	62.6	41.5
	39	120	148	172	289	36.6	63.1	28.3
	34	126	23	172	288	38.8	61.9	4.4

Suction pressure - 2 psig
Rotor end plates - cupped
Disk OD - 5.94 in.
Disk ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 29 - PERFORMANCE WITH CUPPED END PLATE, 0.006-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32	0	83	61	89	2.5	0.0	0.0
	32	10	82	57	87	2.7	41.8	17.8
	32	20	81	56	88	3.4	54.7	28.4
	32	30	80	56	88	3.7	68.9	37.9
	32	40	77	54	88	4.3	72.7	42.2
	32	50	69	52	86	4.9	72.7	41.4
	32	60	58	50	84	5.6	71.1	36.4
	33	69	8	49	82	6.0	72.7	5.7
5000	34	0	166	122	178	6.8	0.0	0.0
	32	10	165	120	178	7.5	25.0	12.9
	33	20	164	118	180	8.3	42.0	23.0
	33	30	161	115	178	9.2	53.3	30.8
	34	40	155	110	175	10.1	60.0	35.9
	34	50	152	106	173	11.1	64.9	40.1
	34	60	143	103	170	12.3	66.3	40.8
	35	70	132	101	166	13.4	67.3	40.5
	35	80	116	98	164	14.4	69.0	37.9
	34	90	65	97	161	15.2	70.8	22.6
	33	93	14	97	161	15.5	71.6	4.9
6000	38	0	238	173	251	11.4	0.0	0.0
	36	20	233	168	258	14.0	33.1	19.4
	37	40	223	158	250	16.6	49.9	31.3
	37	60	212	148	243	19.0	60.3	39.1
	38	80	190	142	236	21.8	65.1	40.8
	37	100	146	135	229	24.9	66.8	34.4
	34	108	18	134	229	26.6	66.4	4.3
7000	42	0	321	233	339	18.6	0.0	0.0
	39	20	314	225	345	21.1	28.1	17.4
	40	40	300	212	336	24.3	44.6	28.8
	40	60	288	202	328	28.4	53.0	35.6
	40	80	273	193	324	32.0	59.6	39.8
	38	100	243	187	316	35.7	63.5	39.7
	34	120	159	180	312	40.6	64.5	27.4

Suction pressure - 2 psig
Rotor end plates - cupped
Disk OD - 5.94 in.
Disk ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 30 - PERFORMANCE WITH CUPPED END PLATE, 0.006-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32	0	82	60	86	2.2	0.0	0.0
	31	10	81	58	86	2.6	28.5	18.2
	31	20	78	55	84	3.1	44.1	29.8
	32	30	77	54	83	3.6	52.2	37.1
	32	40	73	50	81	4.2	56.0	40.6
	32	50	64	48	78	4.7	58.0	39.8
	32	60	55	47	76	5.2	60.4	36.9
	31	70	42	46	75	5.8	61.5	29.7
	31	80	10	44	74	6.3	62.1	7.4
5000	32	0	161	117	168	6.0	0.0	0.0
	31	10	159	114	166	6.9	19.8	13.4
	32	20	154	109	166	7.8	33.8	23.1
	33	30	150	106	164	8.6	44.0	30.7
	33	40	145	101	162	9.7	49.0	34.9
	33	50	142	99	161	10.8	53.5	38.5
	34	60	133	96	156	11.4	58.0	40.8
	34	70	124	93	154	12.5	59.5	40.4
	34	80	109	89	150	13.2	62.4	38.4
	34	90	89	88	149	14.3	63.4	32.8
	33	100	46	86	147	15.3	63.7	17.5
	32	102	16	86	147	15.7	63.2	6.1
6000	35	0	229	164	240	10.6	0.0	0.0
	34	20	221	155	237	13.3	27.6	19.4
	34	40	209	144	232	14.6	48.1	33.5
	35	60	198	137	229	17.1	57.8	40.6
	35	80	179	130	222	20.3	60.9	41.3
	34	100	141	126	216	23.3	62.8	35.5
	32	116	21	123	212	25.7	63.6	5.7
7000	38	0	310	220	320	16.8	0.0	0.0
	36	20	300	207	319	18.7	26.8	18.8
	37	40	285	195	312	21.5	43.4	30.9
	38	60	273	186	311	25.3	52.9	37.7
	38	80	257	178	305	28.7	59.5	41.9
	38	100	228	173	298	32.9	61.6	40.5
	36	120	175	167	292	36.1	64.9	33.9
	31	130	27	167	291	38.8	64.6	5.3

Suction pressure - 50 psig
Rotor end plates - cupped
Disk OD - 5.94 in.
Disk ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 31 - PERFORMANCE WITH CUPPED END PLATE, 0.006-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32	0	86	62	90	2.6	0.0	0.0
	31	10	85	62	90	3.2	30.5	15.7
	31	20	84	61	90	3.6	49.3	27.3
	31	30	80	58	89	4.1	59.5	34.8
	32	40	77	54	87	4.6	64.4	39.1
	31	50	72	52	85	5.3	69.9	42.4
	31	60	58	50	83	5.7	70.2	37.3
	32	70	46	49	80	6.1	70.1	31.1
	31	78	12	46	80	6.5	70.1	8.2
5000	33	0	167	122	178	6.8	0.0	0.0
	31	10	166	120	180	7.6	24.7	12.8
	32	20	165	119	179	8.4	41.8	23.1
	32	30	158	113	177	9.6	48.6	28.7
	33	40	153	108	172	10.4	56.3	34.3
	33	50	148	104	170	11.4	61.5	38.2
	34	60	140	100	166	12.7	61.6	38.7
	34	70	128	98	162	13.3	66.2	39.4
	34	80	114	96	160	14.5	66.3	36.5
	34	90	92	94	158	15.4	67.9	31.4
	34	100	17	94	156	16.5	68.8	6.0
6000	38	0	238	174	250	12.2	0.0	0.0
	36	20	234	169	257	14.0	33.4	19.6
	37	40	221	156	248	16.2	51.8	31.9
	37	60	209	146	238	19.0	59.3	38.4
	37	80	189	140	234	22.3	63.0	39.5
	37	100	148	133	227	25.2	65.2	34.2
	34	116	22	132	222	31.8	57.8	4.9

Suction pressure - 50 psig
Rotor end plates - cupped
Disk OD - 5.94 in.
Disk ID - 1.5 in.
Disk thickness - 0.005 in.

TABLE 32 - PERFORMANCE WITH CUPPED END PLATE, 0.035-IN. SPACING
4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32	0	78	56	76	2.0	0.0	0.0
	31	10	72	50	75	2.3	29.1	18.1
	32	20	69	46	72	2.6	47.3	30.7
	32	30	64	45	70	3.0	55.7	37.7
	32	40	58	41	69	3.7	56.0	37.2
	32	50	49	39	66	4.1	57.5	34.6
	32	60	37	37	64	4.7	57.4	27.7
	32	70	23	36	62	5.2	57.6	18.1
	32	75	10	34	61	5.6	56.2	7.6
5000	33	0	153	112	154	5.8	0.0	0.0
	31	40	127	86	138	9.1	45.4	32.6
	32	60	109	79	132	10.8	56.2	35.6
	32	70	95	76	130	11.5	55.4	33.7
	32	80	79	75	127	12.3	57.4	29.9
	31	90	58	74	125	13.3	59.1	22.9
	30	100	16	71	123	14.5	56.6	6.3
6000	38	0	219	160	222	10.3	0.0	0.0
	36	40	187	126	202	14.3	42.9	30.5
	36	60	171	118	194	16.4	51.8	36.6
	36	80	142	111	188	18.6	57.4	35.9
	36	90	125	109	185	20.2	57.2	32.5
	35	100	102	106	182	21.5	57.7	27.7
	33	110	60	104	178	23.2	57.1	16.7
	30	116	22	101	176	23.7	58.2	6.3
7000	45	0	298	215	304	15.5	0.0	0.0
	43	40	248	170	273	21.9	37.4	26.6
	43	80	216	155	260	27.7	52.8	36.5
	43	100	178	148	251	31.1	55.2	33.4
	42	110	150	143	247	32.2	57.4	29.9
	40	120	114	140	243	34.3	57.4	23.3
	37	130	58	139	240	36.0	58.0	12.2
	33	133	28	138	239	38.0	55.7	5.6

Suction pressure - 50 psig
Rotor end plates - cupped
Disk OD - 5.94 in.
Disk ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 33 - PERFORMANCE WITH CUPPED END PLATE, 0.035-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32	0	88	63	92	2.8	0.0	0.0
	31	10	85	59	90	3.3	28.3	14.9
	32	20	82	56	87	3.7	44.8	25.5
	32	30	76	54	85	4.3	51.6	31.0
	32	40	72	50	82	4.7	58.0	35.3
	32	50	63	49	80	5.2	62.3	35.3
	32	60	48	48	78	5.9	61.5	28.7
	33	70	29	46	76	6.3	63.7	19.0
	33	74	9	44	75	6.8	60.6	5.7
5000	36	0	172	124	188	8.0	0.0	0.0
	35	20	160	112	173	9.8	31.3	19.2
	35	40	148	103	164	11.4	47.0	30.4
	36	50	140	98	162	12.2	52.5	33.5
	36	60	130	94	158	13.4	54.2	34.0
	36	70	116	92	154	14.4	56.2	32.7
	36	80	98	90	152	15.3	58.7	29.8
	36	90	71	88	149	16.2	60.5	23.1
	35	96	18	88	149	17.5	58.4	5.7
6000	43	0	244	176	249	13.0	0.0	0.0
	41	40	214	148	237	17.2	44.8	29.0
	41	60	196	138	229	20.4	51.5	33.6
	41	80	167	131	220	23.6	54.8	33.1
	40	90	148	128	218	25.4	55.4	30.6
	39	100	124	126	215	26.3	57.9	27.5
	38	110	71	124	212	27.9	58.7	16.4
	35	115	24	123	212	29.2	58.3	5.6
7000	51	0	323	234	330	18.4	0.0	0.0
	47	40	288	198	317	26.0	37.8	25.9
	48	80	247	176	297	33.6	50.9	34.3
	47	100	204	167	286	37.4	53.6	31.7
	46	110	180	166	284	38.1	56.2	29.8
	42	120	134	164	281	40.5	57.1	23.1
	37	130	31	162	280	43.8	57.5	5.4

Suction pressure - 50 psig
Rotor end plates - cupped
Disk OD - 5.94 in.
Disk ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 34 - PERFORMANCE WITH CUPPED END PLATE, 0.07-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	33	0	74	54	76	2.4	0.0	0.0
	32	20	65	44	70	3.2	34.2	23.7
	32	30	61	40	66	3.4	44.7	31.3
	32	40	56	39	64	3.8	50.6	34.6
	31	50	44	36	62	4.4	50.6	29.9
	31	60	33	35	60	4.8	51.8	23.9
	30	70	11	34	58	5.2	53.5	8.6
5000	33	0	149	108	153	6.6	0.0	0.0
	32	40	120	82	131	8.8	45.0	31.9
	32	60	102	76	126	10.3	53.0	34.9
	32	70	87	74	123	11.7	51.8	30.6
	32	80	70	71	120	12.3	54.2	25.5
	31	90	30	69	118	13.4	54.0	11.9
	30	91	15	69	117	13.7	52.9	5.9
6000	36	0	212	154	220	10.7	0.0	0.0
	34	40	177	120	194	14.7	39.8	28.2
	34	60	162	113	186	16.2	50.3	35.0
	34	80	132	105	176	19.2	51.6	32.0
	33	90	112	104	174	20.4	53.2	29.0
	31	100	76	100	171	21.3	54.9	21.0
	29	105	19	99	170	22.6	53.5	5.2
7000	43	0	283	206	296	15.9	0.0	0.0
	40	40	242	164	265	21.0	37.9	26.8
	40	80	206	148	247	27.2	51.2	35.3
	39	100	164	141	238	30.3	54.0	31.6
	37	110	126	138	235	31.8	55.4	25.6
	33	120	24	135	232	34.3	54.6	4.8

Suction pressure - 50 psig
Rotor end plates - cupped
Disk OD - 5.94 in.
Disk ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 35 - PERFORMANCE WITH CUPPED END PLATE, 0.07-IN. SPACING, 4:1 RADIUS RATIO ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	33	0	84	60	87	3.2	0.0	0.0
	32	20	75	52	82	3.9	39.0	22.4
	32	30	72	48	78	4.3	47.4	28.9
	32	40	66	47	76	5.0	49.7	30.5
	32	50	54	44	74	5.4	54.8	29.3
	31	60	40	43	72	5.8	57.7	24.3
	31	70	18	42	70	6.4	57.2	11.1
	31	71	10	42	70	6.6	55.9	6.3
5000	35	0	165	120	174	7.6	0.0	0.0
	33	40	139	96	156	11.2	46.0	28.9
	33	60	119	89	148	13.1	52.9	32.1
	33	70	104	86	146	14.0	55.0	30.2
	32	80	84	84	142	15.3	55.2	25.6
	31	90	38	83	141	16.3	56.6	12.5
	29	92	17	82	140	16.9	55.1	5.4
6000	41	0	230	166	241	12.5	0.0	0.0
	39	40	198	136	223	17.1	42.6	27.1
	39	60	182	128	214	19.6	50.7	32.4
	39	80	149	121	206	22.8	53.4	30.7
	38	90	127	118	202	24.0	55.1	27.9
	37	100	88	116	198	25.3	56.2	20.4
	33	105	20	115	198	26.8	55.6	4.6
7000	48	0	306	222	322	18.2	0.0	0.0
	45	40	270	186	301	25.7	36.7	24.5
	45	80	227	166	280	32.6	50.1	32.6
	44	100	182	157	270	36.1	53.0	29.5
	41	110	148	155	267	37.7	54.9	25.1
	36	119	25	154	268	41.9	52.8	4.1

Suction pressure - 50 psig
Rotor end plates - cupped
Disk OD - 5.94 in.
Disk ID - 1.5 in.
Disk thickness - 0.031 in.

TABLE 36 - PERFORMANCE WITH 0.035-IN. SPACING,
ROUGHENED DISK ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.7	0	73	52	77	1.9	0.0	0.0
	32.2	10	71	51	78	2.3	30.8	18.1
	32.4	20	70	49	77	2.7	47.6	30.3
	32.3	30	68	48	75	3.2	55.1	37.1
	32.2	40	64	48	75	3.6	63.5	42.2
	32.1	50	57	46	73	4.1	65.7	41.0
	31.8	60	46	44	72	4.6	65.6	35.2
	31.3	70	33	44	71	5.1	67.1	26.7
	30.6	76	12	43	70	5.4	67.5	10.1
5000	32.5	0	143	105	155	5.8	0.0	0.0
	31.7	10	140	102	155	6.3	21.4	13.1
	32.2	20	139	100	155	7.1	35.3	22.8
	32.3	30	136	98	153	7.7	47.1	31.0
	32.4	40	135	97	151	8.5	54.2	37.2
	32.7	50	129	94	148	9.8	55.1	38.5
	32.5	60	120	92	147	10.5	60.6	40.3
	32.3	70	110	89	145	11.4	62.9	39.3
	31.7	80	97	89	145	12.5	64.4	36.4
	30.7	90	76	87	143	13.6	64.6	29.6
	28.8	98	19	85	142	14.4	65.4	7.6
6000	35.0	0	205	151	225	9.9	0.0	0.0
	32.5	20	199	144	223	12.0	30.0	19.4
	32.7	40	196	139	220	13.7	49.2	33.4
	32.2	60	184	134	215	16.6	56.7	38.9
	32.0	80	162	131	213	19.2	62.2	39.4
	31.6	100	126	127	209	21.2	67.3	34.7
	30.4	113	23	124	207	23.4	67.5	6.6
7000	35.5	0	275	203	303	15.6	0.0	0.0
	32.9	20	269	195	304	18.3	26.2	17.1
	34.1	40	264	189	300	21.3	42.2	28.9
	34.8	60	256	185	296	24.8	51.7	36.3
	35.1	80	236	180	292	27.7	59.3	39.9
	34.8	100	206	175	287	31.3	62.7	38.4
	33.3	120	150	171	286	34.6	66.6	30.3
	30.4	129	29	168	283	36.8	66.4	5.9

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 37 - PERFORMANCE WITH 0.035-IN. SPACING,
ROUGHENED DISK ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.9	0	78	58	84	2.1	0.0	0.0
	32.4	10	76	55	82	2.6	42.9	17.1
	32.7	20	73	53	81	3.0	62.0	28.8
	32.6	30	71	51	80	3.6	65.0	34.8
	32.6	40	66	50	79	4.1	69.1	37.8
	32.7	50	60	48	78	4.5	75.3	39.7
	32.5	60	49	46	76	5.0	74.5	34.2
	32.1	70	35	46	75	5.5	75.8	26.7
	31.9	76	11	44	74	5.9	73.8	8.9
5000	33.9	0	152	113	167	7.1	0.0	0.0
	32.1	10	149	109	165	7.7	22.1	11.3
	32.6	20	146	107	164	8.3	38.2	20.4
	32.6	30	144	104	162	9.4	46.3	26.7
	32.6	40	142	102	161	10.5	52.5	31.6
	32.9	50	135	100	159	11.0	60.6	36.2
	33.7	60	126	98	157	12.4	60.4	35.6
	34.1	70	113	96	154	12.9	65.1	35.7
	34.5	80	97	94	152	14.4	63.6	31.6
	34.1	90	79	92	151	15.1	67.1	27.5
	32.3	98	20	91	150	16.2	65.8	7.2
6000	34.2	0	216	161	239	13.0	0.0	0.0
	32.1	20	209	153	238	14.5	29.4	16.8
	32.1	40	203	148	235	17.0	45.8	28.0
	32.7	60	194	143	229	20.0	53.4	34.0
	33.0	80	167	138	225	22.5	59.9	34.8
	32.5	100	128	133	219	24.9	64.2	29.9
	30.5	111	25	131	218	27.3	63.0	5.9
7000	37.2	0	291	216	323	19.1	0.0	0.0
	35.3	20	284	208	324	21.8	25.3	15.2
	36.0	40	279	203	321	24.8	41.7	26.3
	36.6	60	270	196	315	28.4	50.8	33.3
	36.9	80	251	192	311	32.4	56.5	36.2
	36.7	100	218	187	307	36.3	60.3	35.1
	35.0	120	152	179	301	39.5	64.2	26.9
	31.0	127	30	178	299	42.5	62.2	5.2

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 38 - PERFORMANCE WITH 0.070-IN. SPACING, ROUGHENED DISK ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.1	0	73	52	78	1.6	0.0	0.0
	31.8	10	69	48	74	2.1	33.3	18.8
	32.1	20	68	46	73	2.5	50.2	31.3
	32.3	30	66	44	71	3.0	57.6	38.7
	32.3	40	62	43	70	3.4	62.5	42.1
	32.4	50	54	42	69	3.9	64.3	40.0
	32.3	60	41	41	67	4.3	66.4	33.1
	32.8	66	10	41	66	4.8	63.7	8.0
5000	33.4	0	143	104	154	4.8	0.0	0.0
	32.0	10	137	99	149	5.3	26.6	15.0
	32.4	20	133	95	148	6.0	43.3	25.7
	32.6	30	132	93	146	6.9	52.5	33.5
	32.7	40	130	90	144	7.6	60.2	39.8
	32.9	50	126	88	141	8.2	66.1	44.5
	32.9	60	118	85	139	9.6	64.2	43.0
	32.9	70	108	84	136	10.7	63.8	41.2
	32.4	80	89	81	135	11.5	66.3	36.1
	30.9	89	14	79	134	12.4	67.1	5.9
6000	34.7	0	205	150	223	8.8	0.0	0.0
	33.1	20	193	139	213	10.5	34.7	21.5
	33.7	40	189	133	209	12.5	53.2	35.4
	34.1	60	181	127	203	14.8	61.5	42.7
	33.9	80	160	123	198	18.3	61.6	40.8
	32.8	100	103	118	195	20.4	66.1	29.5
	30.9	105	19	117	194	21.4	65.3	5.4
7000	38.1	0	279	204	305	13.9	0.0	0.0
	36.5	20	664	191	293	16.1	30.2	48.1
	37.1	40	259	182	289	18.7	48.6	32.4
	37.4	60	253	174	283	22.4	56.0	39.5
	36.8	80	236	170	276	26.1	60.3	42.2
	35.8	100	204	164	269	28.8	65.0	41.4
	31.3	121	24	157	268	32.6	68.0	5.2

Suction pressure - 2 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 39 - PERFORMANCE WITH 0.070-IN. SPACING,
ROUGHENED DISK ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	33.0	0	74	54	78	1.7	0.0	0.0
	32.6	10	70	50	76	2.0	37.5	20.1
	32.8	20	69	48	74	2.5	50.9	31.8
	33.0	30	67	46	73	2.9	60.9	40.0
	33.1	40	64	44	71	3.4	63.4	43.5
	33.0	50	56	43	70	3.9	65.3	41.4
	32.9	60	46	42	69	4.4	66.3	36.2
	32.6	70	33	42	68	4.8	68.7	27.8
	32.7	76	14	41	67	5.2	67.6	12.0
5000	33.6	0	145	106	156	5.2	0.0	0.0
	32.1	10	140	101	152	5.8	23.7	14.1
	32.3	20	136	97	148	6.4	40.1	25.0
	32.4	30	134	94	147	6.9	52.9	34.0
	32.7	40	133	92	145	7.7	59.7	40.3
	33.0	50	128	89	143	8.7	62.2	42.8
	33.1	60	121	87	141	9.8	63.7	43.4
	33.1	70	111	86	138	10.8	64.2	42.0
	33.2	80	96	84	137	11.7	66.2	38.4
	33.1	90	77	82	135	12.5	67.2	32.2
	32.9	99	20	81	134	13.3	68.1	8.7
6000	35.5	0	207	151	227	9.1	0.0	0.0
	34.2	20	195	140	216	10.6	34.8	21.5
	35.0	40	191	133	212	12.7	52.9	35.2
	35.6	60	183	128	208	15.0	62.0	42.6
	35.6	80	162	124	200	17.7	64.7	42.7
	34.9	100	127	120	197	20.7	65.7	35.9
	33.0	115	25	117	194	22.3	68.1	7.5
7000	40.4	0	280	206	308	14.2	0.0	0.0
	38.2	20	267	193	295	16.3	29.8	19.1
	39.0	40	260	184	292	19.4	46.5	31.2
	39.5	60	254	177	285	22.2	57.2	40.0
	39.3	80	237	172	280	26.0	61.5	42.6
	38.7	100	206	166	272	29.3	64.3	41.0
	36.8	120	146	161	269	32.8	66.9	31.2
	33.5	130	30	160	268	35.0	66.9	6.5

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 40 - PERFORMANCE WITH 0.070-IN. SPACING,
ROUGHENED DISK ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.9	0	79	57	84	2.4	0.0	0.0
	32.4	10	75	53	80	2.8	34.7	15.5
	32.3	20	73	50	78	3.2	52.2	26.5
	32.1	30	70	49	77	3.5	62.9	34.0
	31.7	40	66	48	75	4.1	56.0	37.5
	31.7	50	60	46	73	4.7	66.0	37.4
	32.4	60	48	44	71	5.1	68.4	33.1
	32.7	70	34	43	71	5.5	71.9	25.4
	31.4	75	14	42	70	5.9	68.7	10.4
5000	33.7	0	155	114	167	6.3	0.0	0.0
	32.1	10	148	108	162	7.0	25.9	12.4
	32.5	20	143	103	159	7.5	43.3	21.9
	32.6	30	141	101	155	8.4	53.3	29.3
	33.0	40	139	97	154	9.3	60.2	34.9
	33.4	50	134	95	151	10.6	60.7	37.0
	33.8	60	127	92	148	11.3	64.9	39.5
	33.7	70	116	91	147	12.3	66.6	38.5
	33.4	80	101	88	144	13.4	66.3	35.2
	32.8	90	79	87	142	14.1	68.8	29.4
	31.7	97	21	86	141	15.1	67.3	7.9
6000	35.8	0	220	162	241	10.7	0.0	0.0
	33.5	20	207	151	231	13.0	33.9	18.6
	34.0	40	201	142	226	15.3	51.0	30.6
	34.5	60	192	136	220	18.8	55.8	35.8
	34.6	80	172	132	214	21.2	61.3	37.8
	34.1	100	132	127	208	23.8	64.0	32.4
	32.1	112	26	125	206	25.3	65.9	6.7
7000	41.0	0	299	221	328	16.9	0.0	0.0
	38.2	20	284	206	315	19.4	29.0	17.1
	38.9	40	275	197	309	21.9	47.6	29.3
	39.5	60	268	189	304	26.4	53.9	35.5
	39.7	80	250	182	296	29.4	60.7	39.6
	39.3	100	220	177	290	33.3	63.3	38.5
	37.8	120	152	172	285	37.3	64.9	28.5
	35.1	127	33	171	284	39.2	64.8	6.2

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 41 - PERFORMANCE WITH 0.14-IN. SPACING,
ROUGHENED DISK ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.4	0	69	49	74	1.6	0.0	0.0
	32.1	10	65	46	70	2.1	31.4	17.7
	32.5	20	63	43	68	2.5	48.3	29.7
	32.6	30	61	41	66	2.9	55.0	36.4
	32.6	40	57	40	64	3.3	61.1	40.7
	32.5	50	48	38	63	3.7	64.6	38.2
	32.5	60	32	37	61	4.0	66.9	28.0
	33.1	63	9	37	61	4.3	64.9	7.8
5000	33.2	0	136	101	147	4.8	0.0	0.0
	31.8	10	129	94	141	5.5	24.0	13.8
	32.5	20	124	89	138	6.3	38.1	23.1
	32.8	30	123	86	135	6.8	49.3	31.6
	33.1	40	121	83	133	7.7	54.8	36.7
	33.4	50	115	81	130	8.5	58.6	39.5
	33.6	60	108	79	127	9.0	63.2	41.8
	33.4	70	96	76	125	9.8	65.9	40.2
	32.7	80	71	73	123	11.0	64.1	30.3
	32.1	84	13	73	123	11.6	63.2	5.5
6000	35.1	0	196	145	212	8.6	0.0	0.0
	33.5	20	182	132	200	9.9	35.4	21.4
	34.2	40	174	123	193	12.2	50.7	33.3
	34.6	60	165	117	186	14.2	59.8	40.7
	34.5	80	143	112	181	17.2	60.5	38.7
	33.6	100	55	107	177	19.0	65.1	16.8
	32.3	101	18	106	176	19.5	63.9	5.5
7000	37.6	0	266	198	291	13.6	0.0	0.0
	35.0	20	248	180	276	16.0	28.7	18.1
	35.8	40	239	169	268	18.0	47.3	31.0
	35.9	60	233	162	260	21.2	55.3	38.4
	35.4	80	213	154	252	25.0	58.1	39.8
	34.2	100	178	149	246	28.3	60.6	36.7
	29.6	116	23	144	242	31.1	62.3	5.0

Suction pressure - 2 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 42 - PERFORMANCE WITH 0.14-IN. SPACING,
ROUGHENED DISK ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.7	0	74	54	80	2.1	0.0	0.0
	32.3	10	69	49	75	2.5	43.6	16.2
	32.6	20	66	46	73	3.0	56.1	25.8
	32.8	30	63	43	70	3.4	63.8	32.6
	32.7	40	57	42	68	3.8	66.7	34.7
	32.4	50	49	41	66	4.4	65.3	32.5
	32.0	60	31	40	65	4.7	69.2	22.9
	31.8	62	9	39	65	5.1	64.9	6.4
5000	34.0	0	145	108	158	6.1	0.0	0.0
	32.2	10	138	102	153	6.8	25.6	11.8
	32.5	20	133	97	148	7.5	41.8	20.8
	32.7	30	129	93	144	8.2	52.0	27.6
	32.9	40	126	89	141	8.9	59.0	33.1
	33.3	50	119	86	138	10.0	60.1	34.7
	33.3	60	111	83	135	10.9	62.4	35.8
	32.9	70	98	83	133	11.8	63.6	33.9
	31.7	80	68	79	131	12.7	65.1	25.0
	30.4	84	13	80	130	13.2	64.1	4.8
6000	34.0	0	208	156	227	10.1	0.0	0.0
	31.7	20	192	142	216	11.9	36.7	18.8
	34.1	40	183	132	206	14.3	51.7	29.9
	34.2	60	173	125	198	16.8	58.3	35.9
	34.6	80	148	119	192	19.2	62.7	35.9
	34.0	99	19	114	188	22.0	63.7	5.0
7000	37.7	0	282	210	310	16.0	0.0	0.0
	34.9	20	264	194	297	18.7	29.4	16.5
	35.4	40	253	182	284	21.2	46.1	27.8
	35.8	60	244	173	277	24.3	55.4	35.1
	35.5	80	224	166	269	28.3	58.4	36.9
	34.7	100	189	159	262	32.0	60.5	34.5
	30.1	115	23	154	258	35.1	61.7	4.4

Suction pressure - 2 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 43 - PERFORMANCE WITH 0.14-IN. SPACING,
ROUGHENED DISK ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.5	0	71	51	75	1.9	0.0	0.0
	32.1	10	66	47	71	2.2	29.3	17.1
	32.4	20	65	45	70	2.7	43.7	28.1
	32.6	30	63	42	68	3.1	52.4	35.6
	32.6	40	59	40	66	3.5	57.6	39.4
	32.6	50	51	39	64	3.9	59.6	37.7
	32.4	60	40	38	63	4.3	63.4	32.7
	32.2	70	26	37	61	4.6	66.2	23.3
	32.0	74	12	36	60	5.0	62.0	10.4
5000	33.0	0	138	102	149	5.1	0.0	0.0
	31.8	10	132	96	143	5.6	23.2	13.7
	32.1	20	127	91	140	6.3	38.6	23.6
	32.4	30	125	87	137	7.0	48.5	31.3
	32.5	40	123	85	135	7.8	54.8	36.9
	32.5	50	115	82	132	8.5	59.5	39.5
	32.4	60	109	80	129	9.6	59.5	39.8
	32.6	70	99	78	127	10.6	60.1	38.0
	31.9	80	83	76	126	11.4	62.4	33.9
	31.1	90	61	75	124	12.2	63.6	26.2
	29.8	96	19	74	122	12.7	63.8	8.5
6000	33.8	0	198	146	214	9.0	0.0	0.0
	31.8	20	183	131	202	10.2	34.3	21.0
	32.5	40	176	124	195	13.0	47.2	31.7
	33.2	60	166	116	189	15.0	56.3	38.6
	33.4	80	145	112	183	17.7	59.2	38.2
	32.9	100	106	108	179	20.4	60.4	30.4
	31.7	112	23	105	176	21.6	62.3	7.0
7000	38.1	0	268	200	294	14.2	0.0	0.0
	36.0	20	251	182	280	16.7	27.5	17.6
	36.7	40	242	171	271	18.4	46.3	30.6
	37.1	60	235	164	263	21.4	55.2	38.4
	36.9	80	216	157	256	24.9	59.3	40.5
	36.2	100	184	151	250	28.4	61.3	37.8
	34.1	120	109	146	245	32.3	61.9	23.6
	30.7	126	29	145	244	32.8	63.9	6.5

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 44 - PERFORMANCE WITH 0.14-IN. SPACING,
ROUGHENED DISK ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.8	0	76	55	81	2.1	0.0	0.0
	32.5	10	71	51	76	2.6	37.7	15.6
	32.6	20	67	48	74	2.9	61.5	27.2
	32.6	30	65	45	71	3.3	68.8	34.8
	32.6	40	51	43	70	3.8	70.4	37.7
	32.5	50	54	42	68	4.3	70.0	36.8
	32.4	60	41	41	66	4.8	67.8	29.6
	32.6	70	26	40	65	5.4	67.6	19.8
	33.5	73	14	40	64	5.6	65.1	10.7
5000	33.4	0	147	111	160	6.0	0.0	0.0
	31.8	10	140	103	154	6.7	27.1	12.3
	32.1	20	135	99	150	7.3	44.2	21.6
	32.2	30	132	94	146	8.0	54.6	28.8
	32.4	40	128	91	142	9.2	56.3	32.5
	32.3	50	123	88	139	10.0	60.6	35.9
	32.6	60	114	86	137	10.9	63.4	36.7
	32.7	70	102	84	134	11.9	63.6	35.0
	32.6	80	86	81	131	12.8	64.3	31.2
	32.0	90	59	80	130	13.5	66.9	23.0
	30.7	94	20	79	129	14.0	66.1	7.8
6000	34.8	0	210	157	231	10.0	0.0	0.0
	32.7	20	193	142	219	11.9	37.1	19.0
	33.4	40	186	133	208	14.4	51.6	30.3
	34.0	60	175	126	202	16.6	60.8	37.1
	34.2	80	152	121	194	19.7	61.2	36.1
	33.7	100	109	116	189	22.3	63.2	28.7
	32.3	109	23	114	187	23.4	64.4	6.5
7000	42.3	0	285	212	312	15.9	0.0	0.0
	40.1	20	266	195	298	18.0	30.8	17.3
	39.8	40	255	185	287	21.6	45.1	27.6
	39.5	60	246	175	280	24.6	54.9	35.1
	39.6	80	226	167	271	27.9	59.7	37.8
	39.0	100	191	161	264	31.9	60.8	35.1
	37.3	120	95	155	259	35.2	63.3	19.0
	33.7	123	28	155	257	36.1	62.7	5.6

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 45 - PERFORMANCE WITH 0.26-IN. SPACING,
ROUGHENED DISK ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.8	0	64	48	71	1.7	0.0	0.0
	32.6	10	59	43	66	2.1	29.6	16.1
	32.8	20	56	40	64	2.6	42.5	25.2
	33.0	30	53	38	61	2.9	50.8	31.7
	33.0	40	49	36	59	3.3	54.9	34.4
	32.8	50	40	34	58	3.7	59.4	31.9
	32.4	60	16	33	57	3.9	63.6	14.2
	32.7	61	6	33	57	4.1	62.9	5.3
5000	33.2	0	128	98	141	4.6	0.0	0.0
	32.0	10	119	89	134	5.2	24.5	13.3
	32.1	20	115	83	130	6.0	38.0	22.2
	32.1	30	112	80	126	6.8	46.0	28.7
	31.9	40	110	76	124	7.5	52.5	34.1
	32.0	50	103	73	120	8.2	56.9	36.8
	32.1	60	95	72	118	9.0	58.7	36.8
	31.9	70	81	69	116	10.0	59.2	33.1
	31.3	80	46	67	114	10.8	60.5	19.9
	30.6	82	10	67	114	11.2	59.8	4.3
6000	34.0	0	185	140	203	8.8	0.0	0.0
	31.8	20	168	124	190	9.6	35.2	20.4
	32.7	40	160	114	181	12.0	48.6	31.1
	33.2	60	148	107	174	14.3	55.4	36.3
	33.1	80	125	102	168	16.3	60.2	35.8
	32.0	90	96	99	165	18.0	58.8	28.0
	29.6	97	13	98	164	18.7	60.3	4.0
7000	35.8	0	251	191	279	14.4	0.0	0.0
	33.9	20	231	170	262	16.2	26.7	16.6
	34.9	40	222	159	253	19.2	40.8	27.0
	35.3	60	211	148	242	21.2	51.5	34.8
	35.3	80	190	142	234	24.6	55.1	36.1
	34.3	100	151	136	228	27.0	59.5	32.6
	31.4	112	16	133	224	30.0	57.9	3.5

Suction pressure - 2 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 46 - PERFORMANCE WITH 0.26-IN. SPACING,
ROUGHENED DISK ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.5	0	71	52	75	2.2	0.0	0.0
	32.2	10	65	46	71	2.5	39.1	15.0
	32.7	20	62	43	69	2.9	55.0	24.7
	33.1	30	59	40	65	3.4	59.1	30.6
	33.1	40	54	39	64	3.8	64.2	33.4
	32.8	50	44	37	62	4.3	63.6	30.0
	32.4	60	16	36	60	4.9	60.5	11.4
	32.4	60	9	36	60	5.1	58.4	6.3
5000	33.5	0	138	104	149	5.9	0.0	0.0
	32.2	10	130	96	144	6.7	25.2	11.4
	32.8	20	124	90	138	7.3	40.5	19.8
	33.1	30	121	85	134	8.1	49.1	26.2
	33.5	40	117	82	131	8.9	54.7	30.7
	33.6	50	111	78	127	9.8	57.3	33.2
	33.7	60	102	77	124	10.7	58.4	33.3
	33.5	70	88	74	122	11.7	59.4	30.8
	32.6	80	44	73	120	12.3	62.1	16.7
	31.8	81	13	73	120	12.9	59.2	4.8
6000	34.5	0	198	149	216	10.2	0.0	0.0
	32.9	20	180	133	202	11.6	35.7	18.1
	33.5	40	172	123	192	14.3	48.2	28.1
	33.8	60	158	114	184	16.5	56.0	33.6
	33.8	80	134	108	178	18.5	61.9	34.0
	32.7	95	17	105	174	20.8	60.8	4.6
7000	39.2	0	269	202	294	15.1	0.0	0.0
	37.1	20	247	182	279	16.9	32.3	17.1
	37.5	40	236	169	267	20.8	44.5	26.5
	37.6	60	225	159	256	24.0	52.0	32.8
	37.3	80	203	152	248	27.1	56.9	35.0
	36.1	100	164	145	240	30.0	60.1	31.9
	33.3	111	22	143	238	33.8	57.0	4.2

Suction pressure - 2 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 47 - PERFORMANCE WITH 0.26-IN. SPACING, ROUGHENED DISK ROTOR ON WATER

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.9	0	64	50	71	1.7	0.0	0.0
	32.6	10	61	45	68	2.0	33.2	17.7
	32.5	20	56	41	66	2.3	51.9	28.5
	32.3	30	54	39	63	2.8	56.6	34.6
	32.0	40	50	36	61	3.2	59.1	36.7
	31.7	50	41	35	59	3.5	63.7	34.7
	31.3	60	30	35	57	3.9	64.2	27.5
	31.0	70	15	34	56	4.1	68.4	15.4
	30.3	72	8	33	56	4.4	63.8	8.0
5000	32.9	0	129	98	142	4.7	0.0	0.0
	32.0	10	121	90	136	5.3	24.3	13.3
	32.7	20	117	85	131	5.9	39.9	23.2
	33.1	30	113	81	128	6.8	46.8	29.0
	33.0	40	110	77	125	7.3	55.3	35.2
	32.9	50	104	75	122	8.2	57.8	37.1
	33.3	60	96	72	120	9.0	60.4	37.5
	33.4	70	83	70	117	10.1	59.2	33.6
	33.2	80	68	68	114	10.6	62.2	30.1
	32.8	90	38	67	113	11.3	63.4	17.6
	32.2	92	13	67	112	12.0	60.6	5.9
6000	33.7	0	186	142	206	8.4	0.0	0.0
	32.5	20	170	125	192	9.7	35.0	20.5
	33.5	40	162	116	184	12.3	47.7	30.9
	34.1	60	149	108	177	14.6	54.8	35.9
	34.3	80	125	102	171	16.7	59.4	35.2
	33.8	100	81	99	166	18.7	62.3	25.5
	33.0	107	18	97	164	19.5	62.6	5.9
7000	37.6	0	253	193	282	13.0	0.0	0.0
	35.7	20	233	172	265	15.6	28.6	17.5
	36.6	40	223	160	255	18.2	44.2	28.6
	36.8	60	213	151	246	21.1	52.6	35.4
	36.6	80	194	144	237	23.8	58.0	38.2
	35.8	100	162	137	231	27.4	59.0	34.6
	33.4	120	66	134	227	29.9	62.7	15.6
	30.9	121	26	133	225	31.0	60.4	6.1

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

TABLE 48 - PERFORMANCE WITH 0.26-IN. SPACING,
ROUGHENED DISK ROTOR ON ETHYLENE GLYCOL

Rotor Speed (rpm)	Temperature (°C)	Flow (gpm)	Differential Pressure Across Pump (psi)	Rotor Pressure Rise (psi)		Power (bhp)	Observed Efficiency (%)	
				Static	Total		Rotor	Overall Pump
3550	32.8	0	72	84	77	1.9	0.0	0.0
	32.3	10	67	49	72	2.2	53.9	17.5
	32.6	20	64	45	70	2.6	68.9	28.4
	32.7	30	60	42	68	3.2	69.8	33.6
	32.7	40	55	40	66	3.7	69.2	35.4
	32.7	50	47	39	63	3.9	73.0	35.1
	32.5	60	35	38	62	4.3	74.3	28.6
	32.4	70	20	37	61	4.8	73.6	17.5
	32.1	72	11	37	60	5.1	67.9	9.5
5000	33.5	0	139	105	151	5.5	0.0	0.0
	32.4	10	131	97	146	6.1	30.7	12.6
	32.7	20	125	91	140	6.7	47.7	21.8
	32.8	30	122	86	136	7.7	54.3	27.9
	33.0	40	119	84	132	8.3	61.2	33.5
	33.0	50	113	81	130	9.3	63.3	35.7
	32.8	60	104	79	127	10.1	65.4	36.4
	32.4	70	90	76	124	11.0	65.3	33.6
	31.8	80	74	75	123	11.7	68.5	29.7
	31.4	90	44	73	121	12.7	67.4	18.5
	30.8	93	17	72	121	13.2	65.9	7.3
6000	35.9	0	199	150	219	9.6	0.0	0.0
	34.1	20	181	134	204	11.3	37.5	18.7
	34.7	40	173	124	195	13.9	50.8	29.1
	35.3	60	161	115	188	16.0	59.4	35.3
	35.2	80	136	110	180	18.3	62.8	34.8
	34.1	100	88	105	175	20.8	63.6	24.8
	32.8	106	21	104	173	21.6	64.0	6.2
7000	38.9	0	270	205	297	15.1	0.0	0.0
	36.1	20	250	185	283	17.8	30.1	16.4
	36.6	40	238	172	271	20.6	45.9	27.1
	36.9	60	227	161	261	24.0	52.9	33.2
	36.7	80	206	153	251	26.5	59.1	36.2
	34.0	100	171	146	237	29.9	36.9	33.4
	33.3	120	26	141	239	33.8	62.1	5.4

Suction pressure - 50 psig
Rotor end plates - flat
Rotor OD - 5.94 in.
Rotor ID - 1.5 in.
Disk thickness - 0.0625 in.

Predictions by Crawford and Rice[2] indicated that efficiencies and developed pressures will reach high values if the dimensionless flow-rate parameter U_o is maintained at values less than about 0.5 and if the parameter N_{RE} is maintained between 2 and 8.

These parameters are defined[2] as

$$N_{RE} = \frac{\rho\omega h^2}{\mu}$$

and

$$U_o = \frac{Q_1}{2\pi r_i^2 \omega h}$$

where ρ = density of fluid

ω = angular velocity of rotor

h = spacing between adjacent disks

μ = viscosity of fluid

Q_1 = volume flow rate passing between a pair of adjacent disks

r_i = inner radius of disks.

As shown in Figure 9, values for U_o ranged from about 0.09 to 0.18 at rotor best efficiency point for all evaluations using the 4:1 radius ratio rotor. For the 6:1 radius ratio rotor, it can be determined from tabulated data that U_o varies from about 0.22 to 0.42 at best rotor efficiency point.

None of the rotor configurations yielded efficiencies or pressure rises near those predicted,[2] although the torque required to drive the rotor did approach predicted values. Torque data for the 4:1 radius ratio is plotted in Figure 10. Surprisingly, wide variations in interdisk spacings produced only minor changes in observed rotor efficiencies as can be seen in Figures 11-13. The 4:1 radius ratio with flat-end-plate rotor yielded efficiencies in the 60-65% range for interdisk spacings from

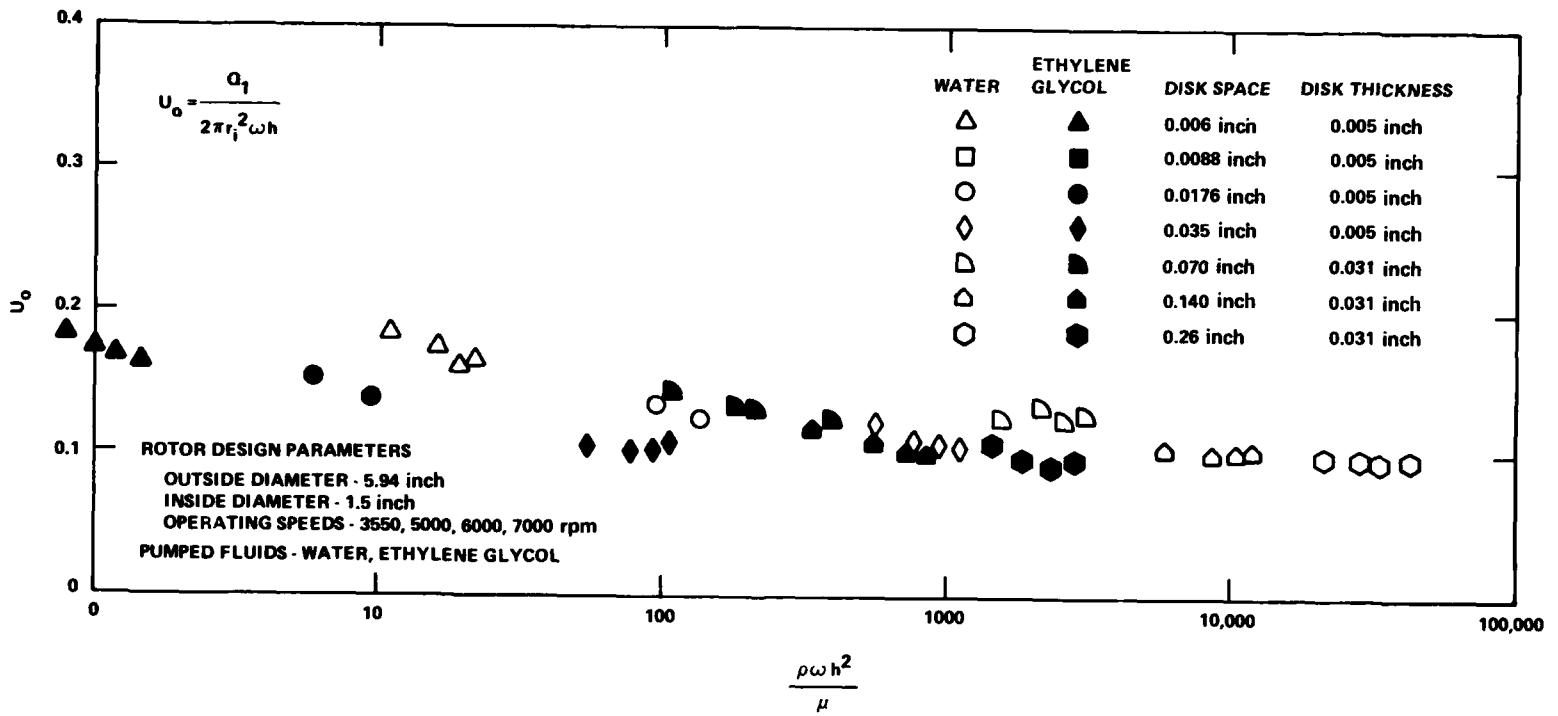

Figure 9 - Observed Values for U_o at Maximum Observed Rotor Efficiency for 5.94-In. Rotor with Flat End Plates

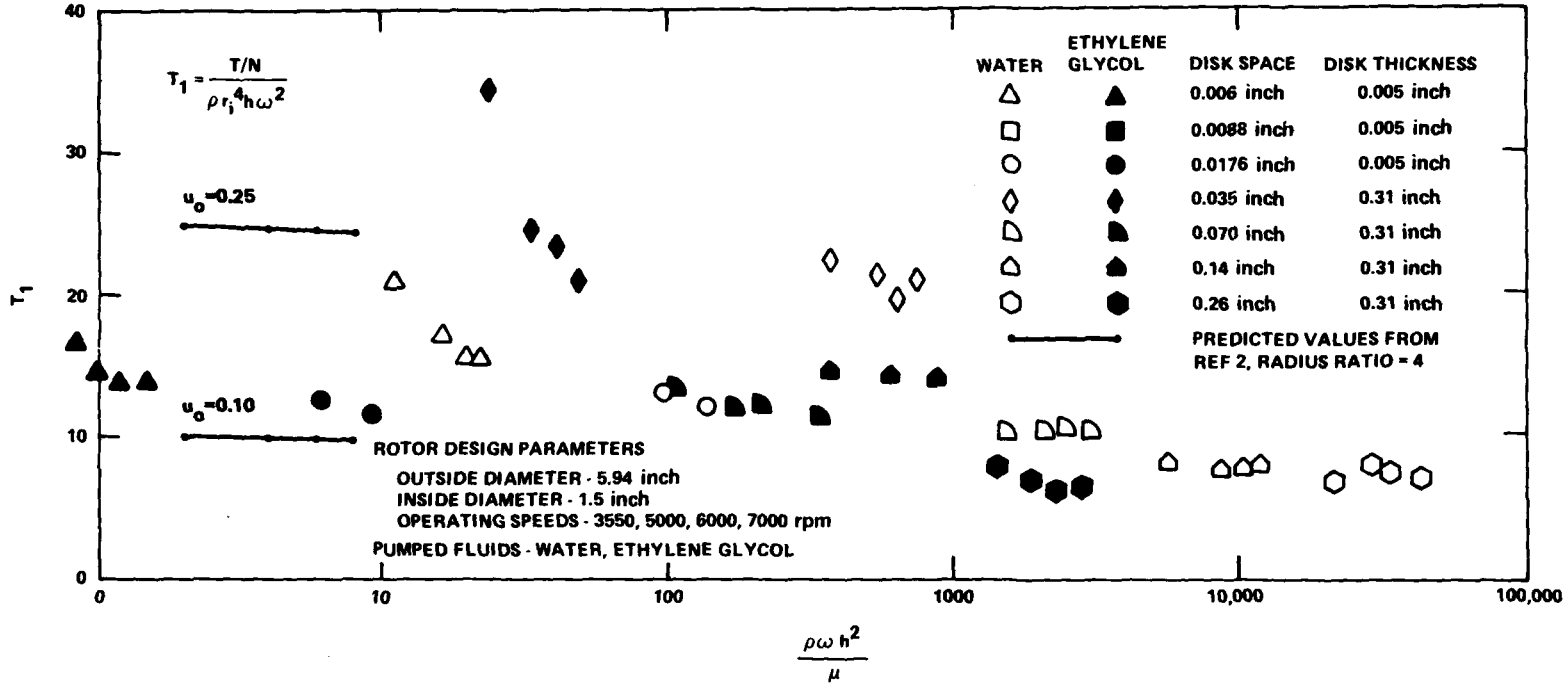

Figure 10 - Observed Values for Torque Parameter at Maximum Observed Rotor Efficiency for 5.94-In. Rotor with Flat End Plates

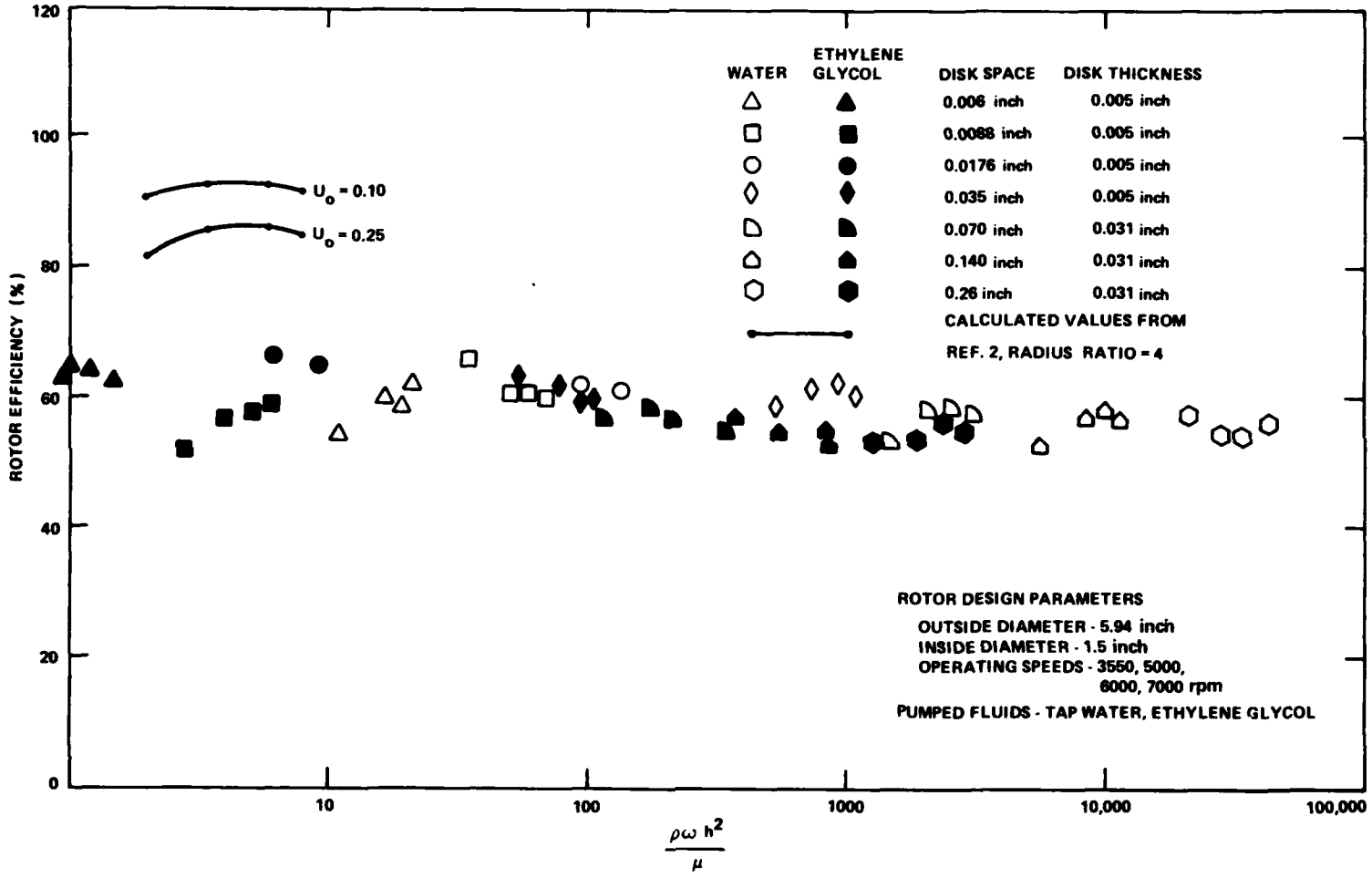

Figure 11 - Maximum Observed Rotor Efficiencies for 5.94-In.-Diam Rotors with Flat End Plates

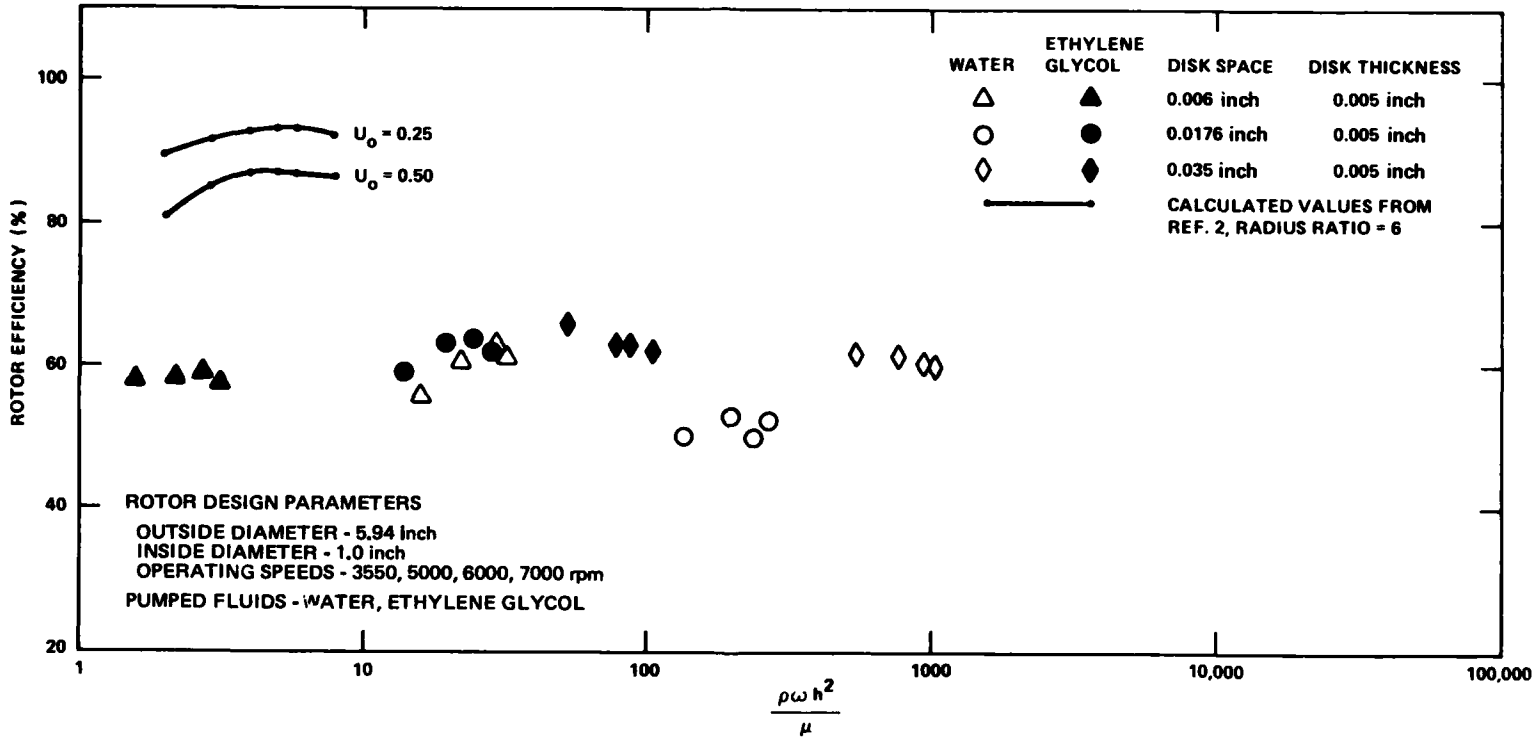

Figure 12 - Maximum Observed Rotor Efficiencies for 5.94-In.-Diam Rotors with Flat End Plates and Radius Ratio of 6

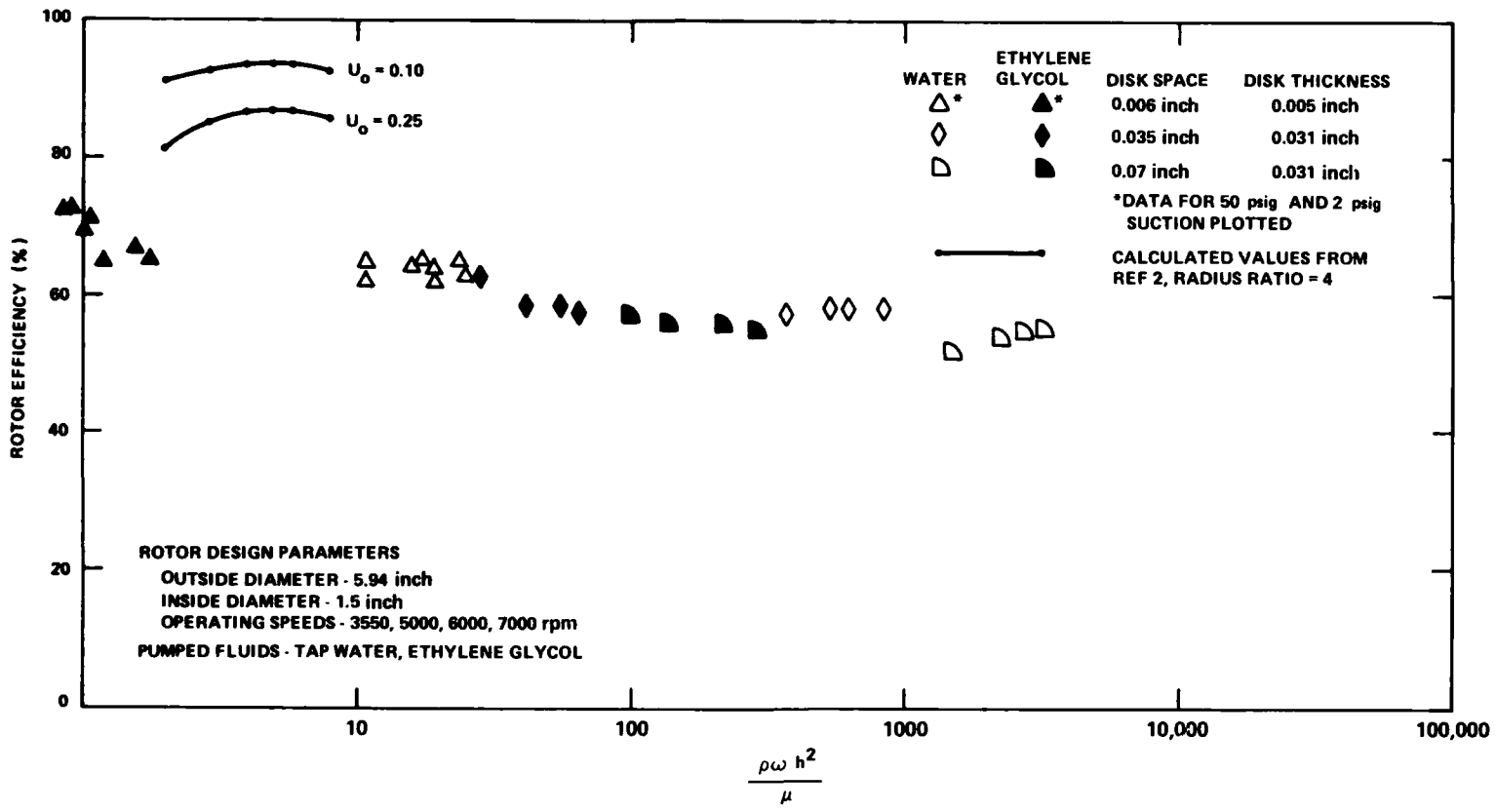

Figure 13 - Maximum Observed Rotor Efficiencies for 5.94-In.-Diam Rotors with Cupped End Plates

0.006 to 0.035 in. (0.15 to 0.89 mm). The same rotor delivered efficiencies of 53-57% with 0.26-in. (6.6-mm) interdisk spacings. Observed values for rotor total pressure rise, Figure 14, also did not approach predicted values, being about 30% below predictions in the operating ranges specified by Crawford and Rice.[2] Total pressure rise did show a decrease for rotor spacings greater than 0.035 in. (0.89 mm) with a corresponding decrease in rotor torque, Figure 10. Total pressure rise for the 6:1 radius ratio rotor remained constant for the disk spacings evaluated, Figure 15.

Rotor static pressure rise, Figure 16, follows the same trends with static pressure for the 4:1 radius ratio rotor below predicted levels by 20-25% for narrow disk spacing rotors and even further below for spacings above 0.035 in. (0.89 mm).

As shown in the tables, most data was taken at 50-psig (3.5-kg/cm^2) suction pressure to ensure freedom from the effects of entrained gases on performance. Several rotor geometries were run at suction pressures as low as 1 psig (0.07 kg/cm^2) and temperatures to 57^{o}C on water with no changes in pump performance noted at any operating speed. Operation at pressures below atmospheric was not possible since the pump shaft seals allowed air intrusion when subjected to a negative pressure gradient.

Improved pumping performance was noted with the roughened disks as shown in Tables 36 through 48 and Figures 17 and 18. Observed rotor efficiencies were generally in the 62-72% range. As with the smooth disks, a slow drop-off in efficiency was noted with increasing disk spacing. Along with the improved rotor efficiencies, improved pump efficiencies were also noted with peak values in the mid- to upper-forties range as compared to maximum values of 30-42% with the smooth disk-rotor configurations. Peak rotor and pump efficiencies tended to occur at the same flow rates for both smooth and rough disks. Significant increases in pressure rise were noted for the roughened as compared to smooth disks. For interdisk spacings of 0.035 and 0.070 in. (0.9 and 1.8 mm) roughened disks produced approximately 20-30% increases in pump pressure, while for spacings of 0.14 and 0.26 in. (3.6 and 6.6 mm) pressure increases of about 14-28% were measured. Observed rotor total pressure rise also followed this trend. As can be seen in Tables 36 through 48 and

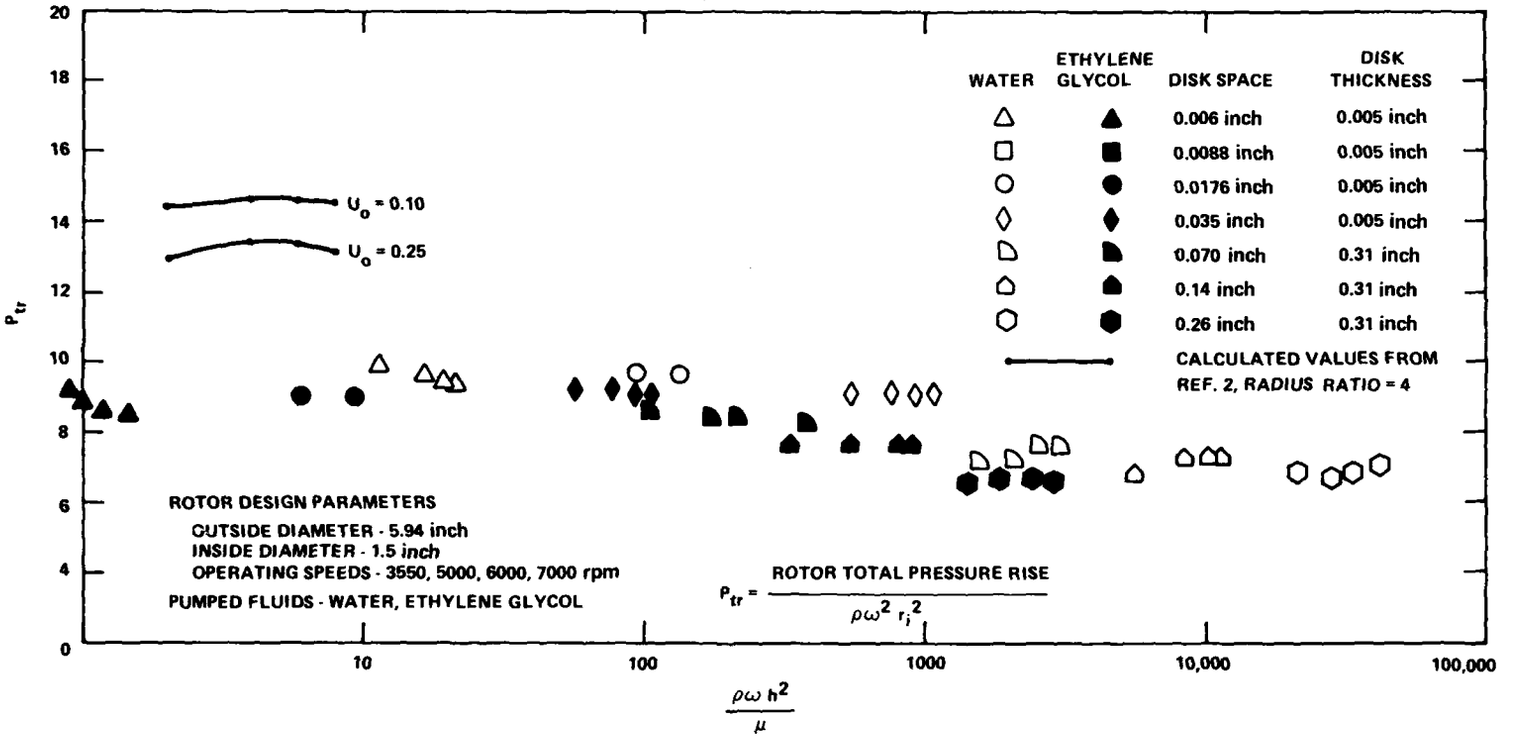

Figure 14 - Observed Values for Rotor Total Pressure Rise at Maximum Observed Rotor Efficiency with Flat End Plates and a Radius Ratio of 4

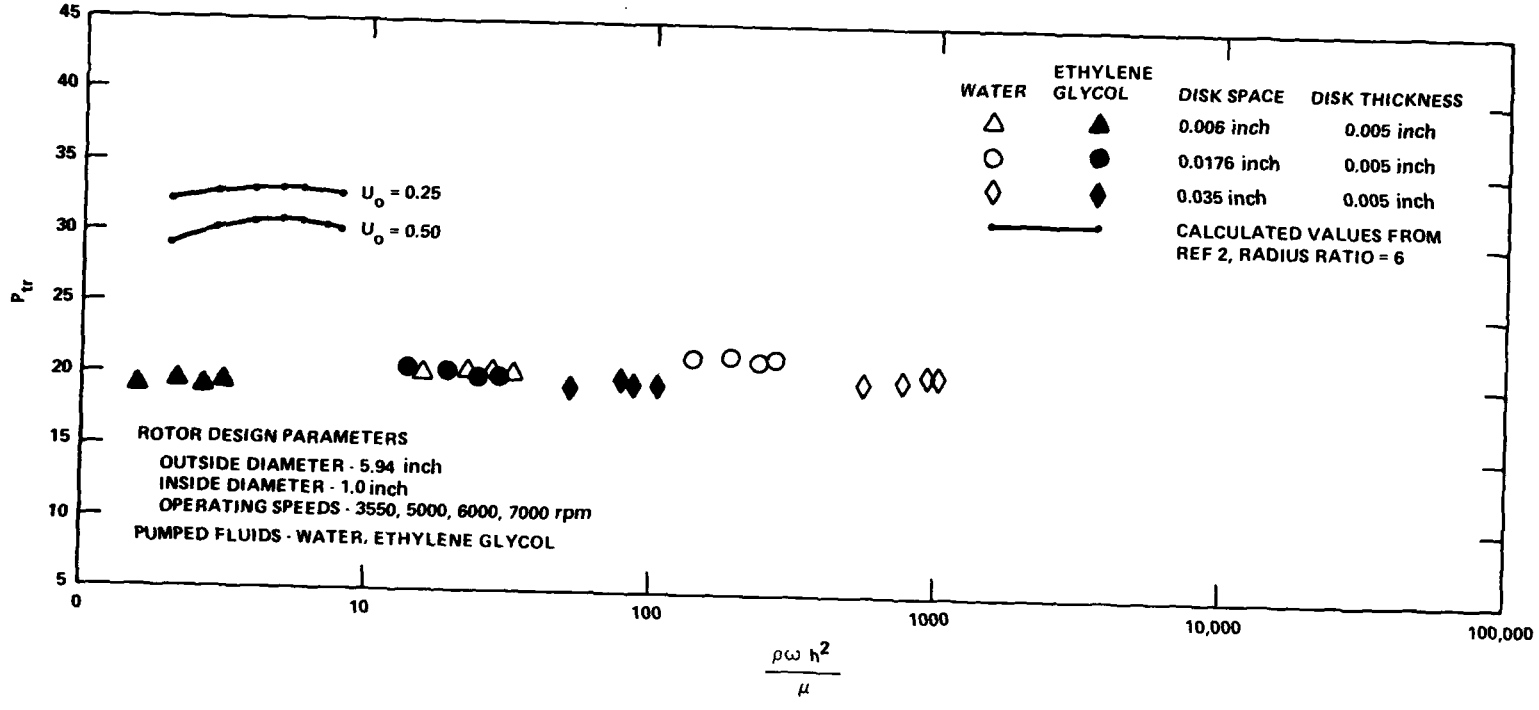

Figure 15 - Observed Values for Rotor Total Pressure Rise at Maximum Observed Rotor Efficiency with Flat End Plates and a Radius Ratio of 6

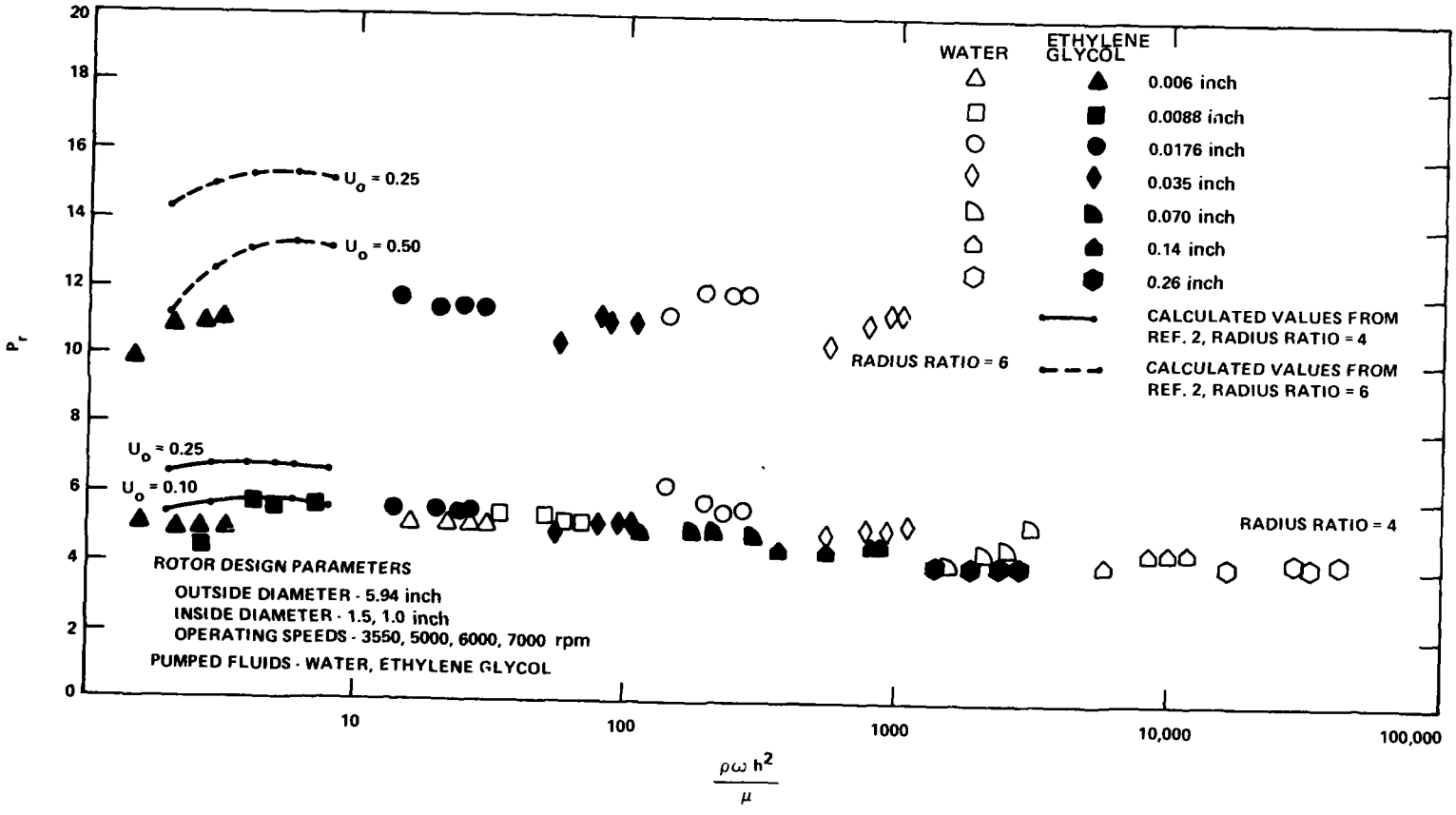

Figure 16 - Observed Values for Rotor Static Pressure Rise at Maximum Rotor Efficiency, 5.94-In. Rotor with Flat End Plates

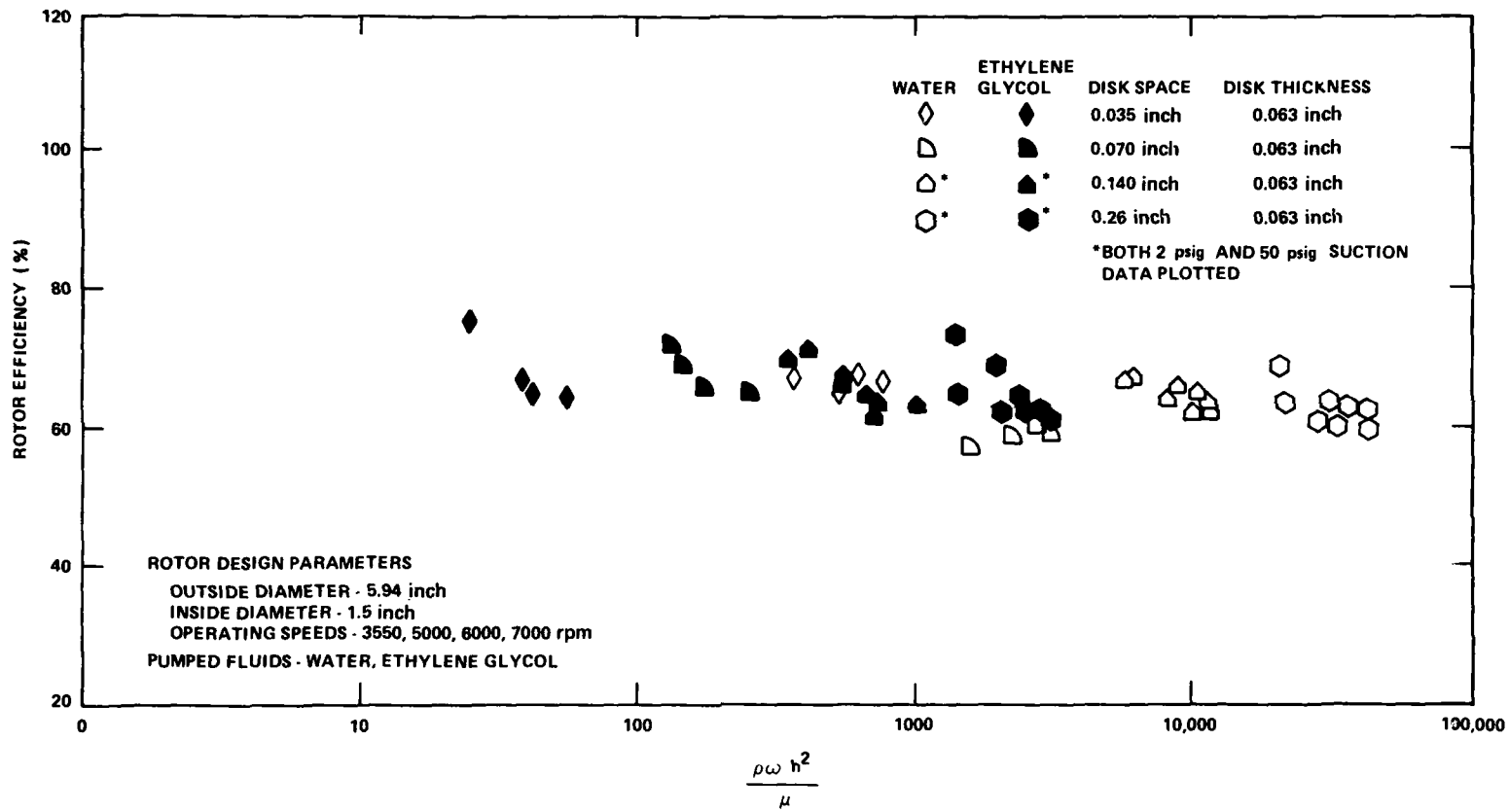

Figure 17 - Maximum Observed Rotor Efficiencies for Rotors with Rough Surface Disks and Flat End Plates

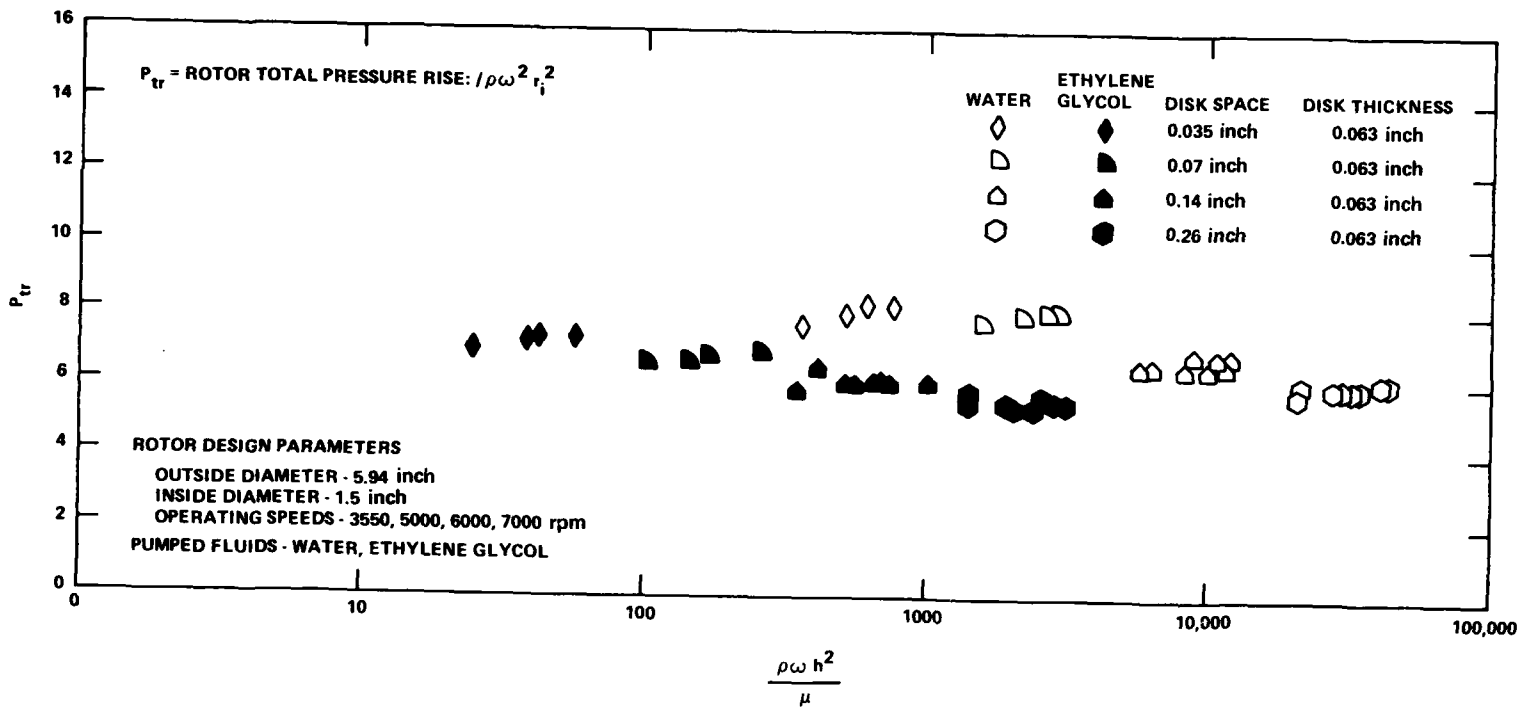

Figure 18 - Observed Values for Rotor Total Pressure Rise at Maximum Observed Rotor Efficiency with Rough Surface Disks and Flat End Plates

Figures 17 and 18, no operational instabilities were observed over the range of suction pressures, speeds, and disk spacings evaluated.

DISCUSSION

ROTOR DESIGN

According to Crawford and Rice's[2] predictions, maintaining certain design parameters within narrow limits would assure laminar flow between the disks with resultant maximum efficiency. The dimensionless parameters reported to have the most significant effects are the design parameter N_{RE}, the volume flow-rate parameter U_o, and the rotor radius ratio. These parameters are defined[2] as

$$N_{RE} = \frac{\rho \omega h^2}{\mu}$$

$$U_o = \frac{Q_1}{2\pi r_i^2 \omega h}$$

$$\text{Radius Ratio} = \frac{r_o}{r_i}$$

where ρ = density of fluid

ω = angular velocity of rotor

h = spacing between adjacent disks

μ = viscosity of fluid

Q_1 = volume flow rate passing between a pair of adjacent disks

r_o = outer radius of disks

r_i = inner radius of disks.

Crawford and Rice[2] predicted rotor efficiencies up to 92.5% for $2 \leq N_{RE} \leq 8$, $r_o/r_i = 4/1$, and $U_o = 0.1$; and at up to 85.9% with $U_o = 0.25$. For a radius ratio of 6:1 and $2 \leq N_{RE} \leq 8$, efficiencies to 92.7 for $U_o = 0.25$ and to 87.2 for $U_o = 0.5$ were predicted. The experimental investigation covered all these design and operating parameters. In addition, operation at points well above $N_{RE} = 8$ were conducted to extend the design data base. Finally, due to an observed insensitivity of efficiency to disk spacing, roughened disks were evaluated in an attempt to improve momentum transfer in the supposedly turbulent flow conditions existing at wide disk spacings.

MEASUREMENT OF FRICTION LOSSES

Within any centrifugal pump, losses occur due to bearing and shaft seal friction, leakage from impeller discharge to suction, and from losses, commonly designated as disk friction, generated between the impeller end plates and the stationary pump casing. Of these, leakage losses and impeller disk friction are the most significant.[5] Leakage losses in the laboratory disk pump designs are eliminated by installation of mechanical face seals on both sides of the impeller. With leakage losses eliminated, seal, bearing, and disk-friction losses were determined through modification of the pump impeller and housing. First, all disks were removed and the two-impeller end plates were bolted directly together. This assembly was then installed in a pump casing with a narrow center section such that all clearances were identical to the normal rotor installation. This configuration was then operated at the speeds and temperatures of interest. Torque readings obtained are a measure of the total losses resulting from disk, bearing, and seal friction. Data is shown in Tables 49 and 50.

PERFORMANCE CALCULATIONS

With the various flow rates, pressures, and torques known, power, pump overall efficiency, and observed rotor efficiency may be calculated.[5]

TABLE 49 - ROTOR FRICTIONAL LOSSES
10-IN.-DIAM ROTOR

Rotor Speed (rpm)	Temperature* (°C)	Water	
		Shaft* Torque τ (in.-lb)	Calculated** (bhp)
1750	26	12	0.33
	59	7.2	0.20
2500	28	28.5	1.13
	60	20.5	0.81
3000	29	48	2.29
	60	40.5	1.93
3550	33	78.8	4.44
	62	69	3.89

*Data points listed are an arithmetic average for ten runs.

**bhp = (τ/12)(rpm)/5250.

TABLE 50 - ROTOR FRICTIONAL LOSSES
5.94-IN.-DIAM ROTOR

Rotor Speed (rpm)	Temperature (°C)	Water*		Ethylene Glycol*	
		Shaft Torque τ (in.-lb)	Calculated** (bhp)	Shaft Torque τ (in.-lb)	Calculated** (bhp)
3550	32	15.3	0.9	26.4	1.5
	66	16.2	0.9	21.8	1.2
5000	32	25.5	2.0	42.4	3.4
	66	26.0	2.1	37.0	2.9
6000	32	35.3	3.4	53.2	5.1
	66	34.8	3.3	46.4	4.4
7000	32	40.3	4.5	63.0	7.0
	66	44.6	5.0	52.8	5.9

*Data points listed are an arithmetic average of five runs.

**bhp = (τ/12)(rpm)/5250).

With torque and speed known, the shaft power supplied to the pump may be calculated from

$$bhp = \frac{2\pi n(\tau/12)}{33{,}000}$$

where n = shaft speed in rpm

τ = torque in in.-lb.

Overall pump efficiency is determined from

$$e = \frac{\text{pump output}}{bhp}$$

$$e = \frac{Q\nu H}{550\ bhp}$$

where Q = flow rate in ft^3/sec

ν = specific weight of liquid being pumped in lb/ft^3

H = pump output head in ft.

Observed impeller efficiency is determined using the actual total head produced by the impeller and the measured frictional losses to determine the actual impeller output and actual power available to the rotor. Actual head increase is obtained by measuring static and dynamic pressure changes across the impeller

$$\text{Total Head} = H = H_d + \frac{V_d^2}{2g} - H_s - \frac{V_s^2}{2g}$$

where H_d = static pressure at impeller discharge in ft

H_s = static pressure at impeller inlet in ft

V_d = velocity at impeller discharge in ft/sec

V_s = velocity at impeller inlet in ft/sec.

Total power to the impeller disk stack is determined by subtracting measured friction-loss power from the power supplied to the pump.

$$\text{Power to disks} = \text{bhp}_{\text{shaft}} - \text{friction-loss power}$$

From the above, observed impeller efficiency becomes

$$\text{Impeller efficiency} = e_I = \frac{\text{impeller output}}{\text{power to impeller}}$$

$$e_I = \frac{Q\nu \left[H_d + \frac{V_d^2}{2g} - H_s - \frac{V_s^2}{2g}\right]}{550 \left[\text{bhp}_{\text{shaft}} - \text{friction-loss power}\right]}$$

The term $H_d + V_d^2/2g$ corresponds to the total pressure at rotor outlet.

PUMP INLET PRESSURES

One of the major advantages of a disk pump was postulated to be its capability of high-speed operation at very low suction pressures.[1] Work reported by Hasinger et al.[1] on disk-rotor cavitation sensitivity indicated that the presence of significant amounts of entrained gases in the pumped fluid would affect rotor performance. To ensure that air intrusion did not affect results during this evaluation, most data was taken at 50-psig (3.5-kg/cm^2) suction pressures. As a check, some data

was also taken at 2-psig (0.14-kg/cm^2) suction pressure with careful attention being given to fluid deaeration before each data run. No significant differences in performance could be detected between the two suction conditions.

FLOW LIMITATIONS

The same pump casing and diffuser ring were used for all data runs with 5.94-in. (151-mm) rotors. A minor modification which did not affect diffuser ring geometry was required to maintain clearance around the cupped rotor end plates.

The casing and diffuser were designed for flow rates predicted[2] for a rotor with the following characteristics:

Outside diameter - 5.94 in. (151 mm)
Inside diameter - 1.5 in. (38 mm)
Disk space - 0.006 in. (0.15 mm)
Disk thickness - 0.005 in. (0.13 mm)
No. of disks - 180
Flow-rate parameter = U_o = 0.10.

Accordingly, the casing and diffuser limited the flow ranges attainable with each rotor to approximately the same values.

ACCURACY OF MEASUREMENTS

Instrumentation employed to measure pump performance is listed in Table 3 along with estimated measurement uncertainties for each system. Torque, flow rate, and pump pressure measurements are straightforward. However, determination of rotor performance is considerably more difficult. Space limitations preclude use of pressure probes larger than the simple pitot-static probe employed. As installed, the probe tip is tangential to the rotor outside diameter and about 1/16-1/8 in. (1.5-3 mm) away from the disk edge for the flat-end-plate rotors. For the cupped end plates the pitot tip was tangent to the ends of the cups and centered between them. As installed, the pitot probes could be aligned with the flow direction parallel to the disk plates but could not

be moved about the plane tangent to the disks. The inability to align with the flow leaving the rotor is a possible error source but is not considered to be very large.

Data presented by Beckwith and Buck[6] indicates error in static and total head readings approaches 6-8% as the angle of misalignment approaches 16 degrees. Laboratory alignment of the pitot tip with a plane tangent to the rotor diameter is always within about ±2 degrees. The actual direction of the fluid velocity vector leaving the rotor must be nearly tangent to the rotor since radial velocity of fluid moving through the rotor is so low, on the order of 1.2-1.9 ft/sec (33.5-58 cm/sec) for the 0.006-in. (0.15-mm) interdisk spacing rotor and 0.5-1 ft/sec (15-30 cm/sec) for the 0.26-in. (6.6-mm) disk spacing rotor at rotor best efficiency point. Radial velocities were calculated using the measured flow rate and actual interdisk flow area at the rotor outside diameter. It may reasonably be assumed that the actual exit velocity magnitude lies between the rotor tip speed and the velocity indicated by the pitot-static probe. For either case, calculated deviation of fluid exit velocity direction does not exceed 1 degree for any of the operating speeds evaluated.

From these considerations a strong case can be made for pitot accuracies within ±2%. This does not take into account the velocity gradient which exists between the rotor and the stationary diffuser ring. However, with the flat end plates approximately 0.5 in. (13 mm) exists between the disks and the diffuser ring. With the pitot located close to the disk, effects of velocity gradient should be minimized. For the cupped rotor, clearance between the cupped end plates and the diffuser was maintained at 0.09 in. (2.3 mm) with the pitot located between the tips of the cupped end plates. Again, with the pitot at the rotor outlet, reasonably good indications of actual conditions should be obtained.

As a final point it should be borne in mind that efficiencies are calculated from measured performance parameters and, as such, include the measurement uncertainty for each measured quantity. Therefore, some scatter in efficiency data is to be expected.

CONCLUSIONS

Laboratory data presented herein indicates that disk pump efficiency did not exhibit a strong dependency on interdisk spacing although developed head did show an effect. Also, at wider disk spacings, roughened surface disks provided improved head and efficiency capabilities. With indications of laboratory rotor efficiencies in the 65-72% range, pump overall efficiencies in the 50-60% range should be attainable with large flow-rate pumps.

These results tend to broaden the applicability of disk-type pumps to practical pumping problems. The high-speed capability and low suction head requirements of the disk rotor have long been of interest to pump designers where these attributes were important. With a capability of operating at wider disk spacing without severe performance penalty, the disk rotor is of much greater practical value. The very narrow spacings indicated in much of the published literature for maximum efficiency operations with most common fluids preclude use of disk rotors due to plugging problems which would arise from the contaminants present in most systems.

A possible application for the disk rotor would be as the first stage of a two or more stage high-speed pump for such applications as boiler feed pumping. In this application, the disk-type first stage would allow high-speed operation at low suction pressures and would produce sufficient head to prevent cavitation in the conventional-bladed second-stage impeller. Such a hybrid pump would offer higher speed capabilities at low suction pressures. Since a portion of the head rise would be accomplished using conventional-bladed impellers, overall pump efficiency could still be quite high while realizing significant size, weight, and complexity reductions due to the higher possible head rise per stage and fewer stages required for a given total pressure rise.

REFERENCES

1. Hasinger, S. H. et al., "Cavitation Tests with a High Efficiency Shear Force Pump," Proceedings, ASME Symposium on Cavitation in Fluid Machinery, Chicago, ILL, pp. 132-147 (7-11 Nov 1965).

2. Crawford, M. E. and W. Rice, "Calculated Design Data for the Multiple-Disk Pump Using Incompressible Fluid," ASME Paper 74-PWR-B (submitted to ASME 6 Feb 1974).

3. Runstadler, P. W. et al., "Diffusor Data Book," Creare, Inc., Hanover, NH, TN-186 (May 1975).

4. Cockrell, D. J. and E. Markland, "A Review of Incompressible Diffusor Flow," Aircraft Engineering (Oct 1963).

5. Stepanoff, A. J., "Centrifugal and Axial Flow Pumps," John Wiley and Sons, Inc., NY, 2nd ed. (1957).

6. Beckwith, T. G. and N. L. Buck, "Mechanical Measurements," Addison-Wesley Publishing Co., Inc. (1961).

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